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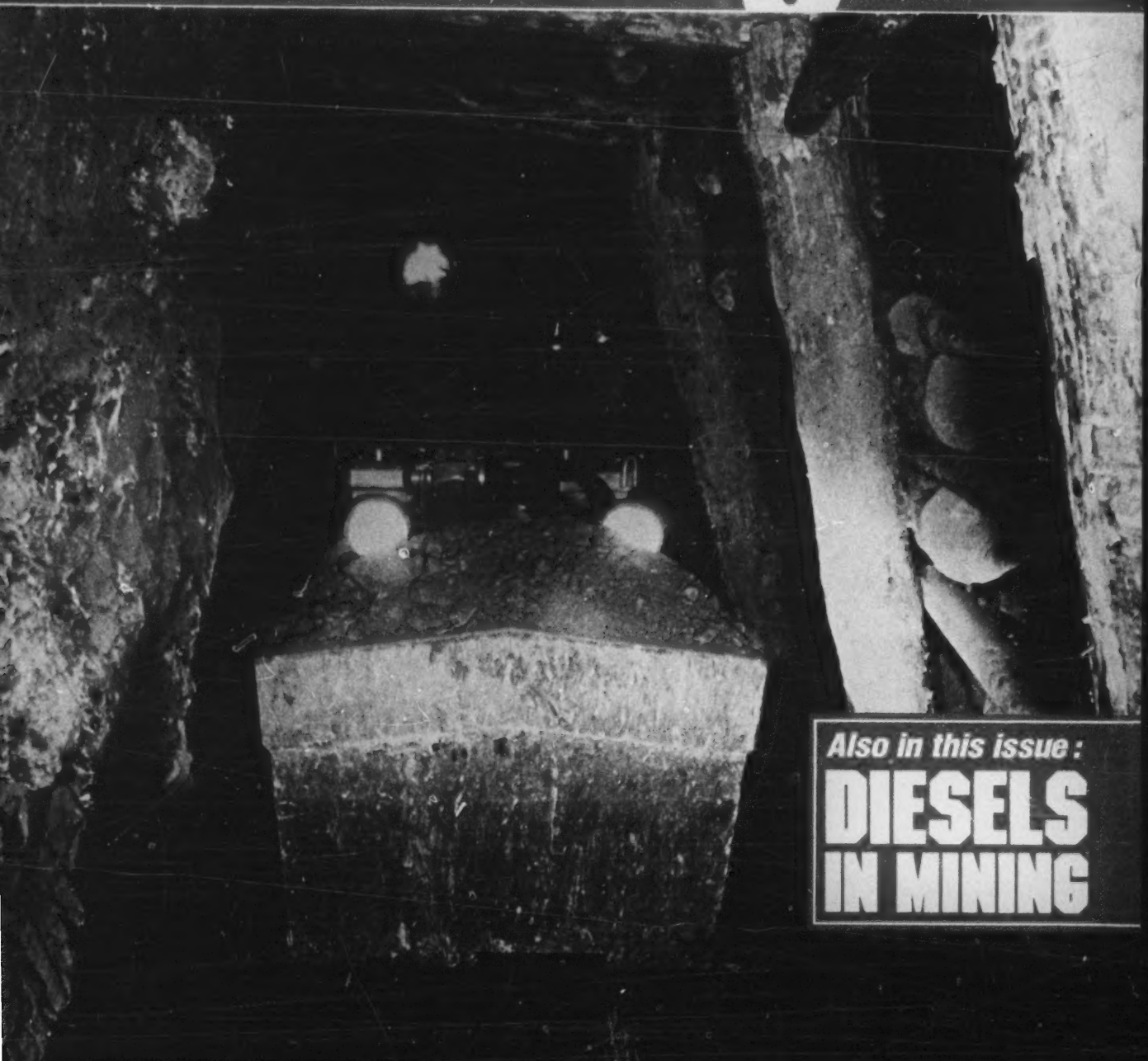
Vertical cutting loader for open pit mines 44

Pressure filters cut costs 50

World Mining

NOVEMBER 1982



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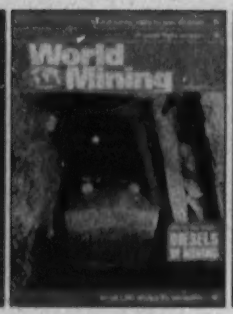

World Mining

NOVEMBER 1982
VOLUME 35, NO. 11

THE COVER

A CT500 Microscoop operates in a narrow area in a lead-zinc mine. The unit is rapidly gaining exoerience around the world. It is especially suited for narrow veins or mineralized faults, since it is only 80 centimeters (2.62 feet) wide. *Photograph courtesy of Equipment Minier.*

Features

***Special Report:* DIESELS IN MINING** **D1**

It is difficult to imagine a mine that uses no Diesel power. The use of Diesels in mining has steadily increased since the invention of the engine in 1892, and the Diesel remains the "work horse" of the industry today. WORLD MINING, in cooperation with Fluor Mining & Metals, Inc., Redwood City, California, United States, presents a comprehensive study of Diesels in the mining industry in this issue, covering surface and underground mines, power generation, Diesel fuels and subsystems, and maintenance. The section begins immediately after the Production Equipment Review

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Wide range of minerals makes Yugoslavia a leading European mining area and important producer of antimony, bauxite, copper, lead, zinc, gold, and silver. Expansions are underway, particularly in the lead-zinc sector

Yugoslavia: mining industry with considerable potential

By **John R. Chadwick**
Associate Editor

Since the end of the Second World War, Yugoslavia has increased its mining production very significantly. For example, electrolytic copper production has increased by a factor of six, to 132,603 metric tons in 1981, steel production has gone up almost 20 times, to 3,976,500 tons in 1981. It now boasts the largest copper mine in Europe, Majdanpek, which produces 14,000,000 tons of ore per year, and the largest bauxite mine in Europe, Vlasenica, which produces a large proportion of the national output. In 1981, bauxite production was 3,249,000 tons, over 4 percent of world output, which ranked the country eighth among the world's producers. It also ranked number 15 in the world and number one in Europe for copper production. Impressive for a country of only 255,804 square kilometers (98,740 square miles). There is great potential for the future.

The country's bauxite reserves have been estimated at around 300,000,000 tons. In 1980 there were plans to increase output from the current level of about 3,300,000 tons a year to 6,000,000 tons by 1985. In view of the current slump, it remains to be seen whether this will be achieved. However, a proposed increase of 200,000 tons was targeted for Vlasenica in 1982 to bring production up to 1,500,000 tons, of which 80,000 tons will be exported to the Soviet Union. Overburden removal for 1982 will be over 5,000,000 cubic meters (6,540,000 cubic yards).

The Vlasenica deposits are in eastern Bosnia, 100 kilometers (62 miles) to the east of Sarajevo. The bauxite-bearing zone stretches for about 30 kilometers (19 miles), between Dinaric and Drina, and is 4 to 5 kilometers (2.5 to 3.1 miles) wide. Individual beds are up to 20 meters (65.6 feet) thick. Mining is by open pit methods although underground operations may be developed in the future. The bauxite, which consists of boehmite with some kaolin and can have a rather high iron content in some deposits, is sent to the nearby Birač alumina plant at Zvornik.

The Nikšić region of Montenegro is another of the major bauxite districts. Recent expansions and purchases of new equipment have raised the underground capacity to 400,000 tons of ore per year. The total output of the company, Boksiti Nikšić, is about 700,000 annual tons with future development aimed at raising output to 1,000,000 tons. These mines supply the plant at Titograd.

The Posušje bauxite mines, west of Mostar in Herzegovina, work many deposits up to 500,000 tons in size. On average they contain about 50 percent alumina. A mixture of open pit mines and an underground operation, employing sub-level techniques, is to be found. The underground mine is currently being modernized by the introduction of rubber-tired Diesel equipment. Northwest of Mostar are small surface and underground mines of the Ličtica area. These and the Posušje mines supply the Mostar alumina plant.

The Grebničke deposit, near the northern border of Albania, 10 kilometers (6 miles) southeast of Klina, has been mined since 1966 and reached a maximum production level of 200,000 tons annually. Depleted reserves and falling grades have reduced this level to about 80,000 tons. The Jajce mines of northwestern Bosnia are located within the districts of Poljane, Crvene Stijene, Bešpelj, Liskovica, Baraći and Srnetica. These numerous deposits vary in grade from 44 to 60 percent Al_2O_3. Output is currently around 340,000 tons per year.

Bauxite deposits of the Istrian peninsula stretch from the town of Umag in the northwest to Labin in the southeast, in a wide belt. The average grade is 53 percent Al_2O_3. Ore production is declining, standing at 120,000 tons, with 350,000 cubic meters (457,800 cubic yards) of overburden stripped per year.

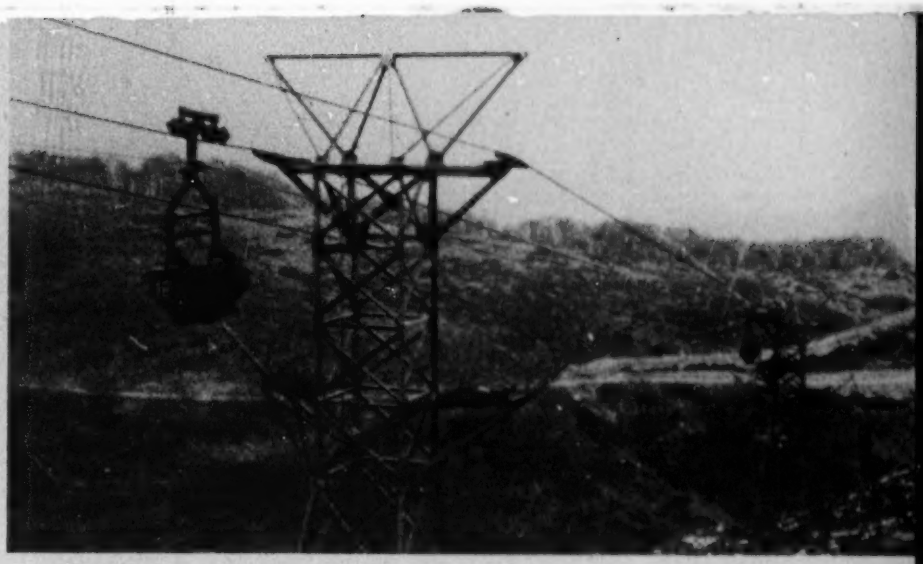
Copper

Rudarsko Topioničarski Basen Bor (RTB Bor), in eastern Serbia, is the largest copper mining company in Europe and, according to the company, its reserves total 2 percent of the world's current known resources. The original mine, Bor, is still operating at a rate of 4,000,000 tons of ore per year from both surface and underground operations. The ore contains 1 to 2 percent Cu, up to 4 grams (0.12 ounce) of gold and up to 10 grams (0.32 ounce) of silver per ton, and significant amounts of germanium, selenium, and nickel, as well as minor amounts of platinum. Below the copper ore currently being mined lies a porphyry deposit from which future production may be derived (see WORLD MINING, December 1979, page 11).

The massive Majdanpek porphyry deposit has been known since Roman times. Modern open pit mining began in 1959 and, by 1961, annual output was 3,600,000 tons of ore. Production has built up steadily to today's level of 14,000,000 tons of ore and 33,500,000 tons of overburden. The ore body is 3 kilometers (1.86 miles) long but fairly narrow, ranging in width from 300 to 600 meters (984 to 1,968 feet). The vertical extent of the ore delineated to date is 1,000 meters (3,281 feet).

Chalcopyrite is the principal copper mineralization, locally accompanied by bornite. Molybdenite is irregularly distributed throughout the deposit. Pyrite content is not high, 2 to 3 percent. Reserves were estimated at 200,000,000 tons in 1978, containing 0.83 percent Cu and 0.005 percent Mo. The average head grade at present is 0.52 percent Cu and recovery by flotation is reported to achieve 86.8 percent.

To the northeast of Bor is RTB Bor's newest mine, Veliki Krivelj, another porphyry deposit. Mineralization includes chalcopyrite, molybdenite, and pyrite as the primary minerals, with trace showings of magnetite, hematite, scheelite, and fluorite. The ore body exceeds 1,000 meters (3,281 feet) in depth. It contains more than 600,000,000 tons of ore at 0.4 percent Cu (see WORLD MINING, December 1979, page 11). The mine's initial production will come from open pit mining, and although development has



IRON ORE from Tajmiste is carried 1,100 meters by tram to Zelezarna steel works.

been delayed, production, at a design rate of 8,000,000 tons of ore per year, is expected to commence soon. The mine's copper output is targeted for 30,000 tons a year, which will raise RTB Bor's total output of electrolytic copper to 123,000 tons by 1983.

Another new mine is Bučim in southwest Macedonia, about 130 kilometers (81 miles) from Skopje. Extraction from this open pit started in 1979; current mine output is 3,700,000 tons of ore per year. This yields 50,000 tons of copper annually and some gold. An expansion to 6,000,000 tons is planned. A new concentrator, under construction, will produce about 100,000 tons of iron concentrate per year. Another deposit, Borova Glava, 8 kilometers (5 miles) to the south and of the same type as Bučim, is under exploration.

Iron Ore

The Damjan magnetite and hematite mine is in southwest Macedonia, about 110 kilometers (68 miles) from Skopje. The ore deposit is 20 to 25 meters (66 to 82 feet) wide and strikes over a length of 800 meters (2,625 feet). To date, it has been explored to a depth of about 200 meters (656 feet). The recent phase of open pit mining began in 1963. Its current schedule calls for the production of 900,000 tons of overburden, 45,000 tons of high-grade ore, 60,000 tons of ore for concentration, and 6,000 tons of agglomeration ore each year. The ore contains 0.5 percent Mn and 52 to 56 percent Fe.

Operated by the same company, Rudnici i Železarnica Skopje, the Tajmište open pit mine came into production in 1969. This mine, in western Macedonia, is situated about 16 kilometers (9.9 miles) from Kičevo. Current output is 1,000,000 tons of ore and 3,000,000 tons of overburden per year. Ore production is to be doubled in the future. Iron concentrate, containing 42 to 44 percent Fe, is produced.

A much larger operation is the Ljubija mine in northwest Bosnia, near Prijedor. Here the overburden removal is 12,000,000 tons a year and ore production reaches 2,200,000 tons annually. This production rate is to be expanded to 20,000,000 tons of overburden and 4,100,000 tons of ore by 1985. Limonite ore mined contains 44 percent Fe, ankerite contains 27 percent Fe, and the siderite contains 37 percent Fe.

The iron and copper deposits of Suva Ruda and Suvo Rudihšte are in the central Kapaonik area. The average content of the ores is 26.8 percent Fe_3O_4 and 0.96 percent Cu. The Suvo Rudište ore also contains 0.4 percent Mn. Mining here produces 300,000 tons of ore per year.

Mining from Suva Ruda began in 1972, employing both underground and surface methods. The output was steady at 250,000 tons but is now decreasing due to depleted reserves. Magnetite concentrate, containing 69 percent Fe, is produced. The copper concentrate from these mines is delivered to RTB Bor. Due to the depletion of iron and copper ore reserves at Suva Ruda, exploration is concentrating on lead and zinc in the area. Some changes will obviously be required in the flotation plant to move to lead-zinc production. But it is thought that up to 10,000 annual tons of magnetite could still be produced.

Lead and Zinc

Lead and zinc mines are widespread throughout the country. The largest and best known is the Trepča mine, in the Kopaonik area. The deposit, which is actually located at Stari Trg, 8 kilometers (5 miles) east of Trepča, still has reserves of at least 50,000,000 tons of ore. It contains 5 to 7 percent Pb and 4 percent Zn. The pyrite and pyrrhotite content exceeds 50 percent. The sphalerite mineralization contains 1 to 2 percent cadmium. The ore bodies are pipe-shaped with surface areas varying from 50 to 7,000 square meters (538 to 75,350 square feet). To date, about 40 separate ore bodies have been identified. Mineralization extends below 1,300 meters (4,265 feet), the limit to which it has been explored.

Mined since the Middle Ages, Trepča is currently worked by cut-and-fill techniques. The present annual production is 600,000 tons of ore. In the same ore field are the deposits of Mažić, Meljenica, and Zijača, which contain important ore reserves.

Further to the south are the mines of Kišnica and Novo Brdo, 10 and 40 kilometers (6 and 25 miles) to the southeast of Priština, respectively. The Novo Brdo mine is currently scheduled for expansion to 450,000 tons of ore annually. These mines supply the Trepča metallurgical plant and, at present, supply 32 percent of the lead concentrate, 31 percent of the lead and 38 percent of the silver received.

The Kapaonik Mining Company works four deposits in the Kapaonik area (Belo Brdo, Crnac, Žuta Prlina, and Koporić) and also supplies the Trepča metallurgical plant. Annual output from Belo Brdo is 100,000 tons of ore containing 8 percent lead and zinc, using cut-and-fill. An increase to 150,000 tons is planned for 1984. The Crnac mine produces 60,000 tons containing 7 percent Pb and 2 percent Zn, by sub-level open stoping. Output should reach 150,000 tons by 1983.

Žuta Prlina is being expanded by moving into the Jekalce mining area. Output will be increased by 20,000 tons to 80,000 tons, averaging 2 percent Pb and 5 percent Zn, by 1983. The Koporić open pit is the largest of these mines with a current output of 160,000 tons per year. However, due to falling grades and expansions at the other mines, its output will decrease to 115,000 tons by 1984. This ore has always been low-grade, averaging 2 percent Pb and 1 percent Zn in the past.

The Brskovo mines are located on the northwest slopes of Mount Bjelasica, near the town of Mojkovac in Montenegro. In the past this ore field was a significant producer of silver. Modern mining began in 1976 with open pits and underground operations, employing sub-level open stoping and sub-level caving. Underground output is 22,000 tons and that of the open pit is 230,000 tons of ore

per year. An expansion program should raise production to 100,000 annual tons of concentrate containing lead, zinc, and silver.

Also in Montenegro, on the northwest slope of Mount Ljubišnja, 42 kilometers (26 miles) from Pljevlja, is the Šuplja Stijena deposit. This has been mined since the Middle Ages as well. Immediately after World War II, exploration began. Since then, exploration and pilot plant testing have proceeded. The ore contains 6 to 8 percent Zn, 2 to 4 percent Pb, and 30 percent pyrite.

The work has delineated 1,600,000 tons of ore suitable for extraction underground and 20,100,000 tons for surface mining. Pilot underground and open pit mining was carried out from 1980. In 1983 the development plan schedules the processing of 310,000 tons of ore and the production of 2,114 tons of lead, 13,083 tons of zinc, and 10,000 tons of pyrite concentrate. Further plans until 1985 envisage the extraction of other economic constituents such as rare earth metals, copper, silver, gold, cadmium, bismuth, and silica sand.

South of Belgrade, 100 kilometers (62 miles), is the Rudnik mine. The economic constituents of this ore are 0.4 to 7.4 percent Pb, 0.3 to 5.7 percent Zn, 0.15 to 1.19 percent Cu, 25 to 155 parts of gold per million, 13 to 698 parts of bismuth per million, and 50 to 272 parts of cadmium per million. All are recovered, with the galena concentrate averaging 0.33 percent Ag and 0.7 percent Bi. Output is currently 200,000 tons of ore per year, targeted for an increase to 230,000 tons by 1984. Mining is by sublevel open stoping and caving.

Yugoslavian production of metals and minerals in metric tons

Commodity	1979	1980	1981
Refined lead	111,040	101,751	96,401
Zinc	98,905	84,537	98,370
Electrolytic copper	137,500	131,288	132,603
Antimony regulus	2,401	2,237	2,198
Mercury	—	2	6
Aluminum	189,522	184,760	189,787
Bismuth[1]	23,000	82,800	102,400
Selenium[1]	50,600	50,400	61,000
Silver[1]	162,000	149,000	138,100
Gold[1]	N.A.	N.A.	17,420
Pig iron	2,360,000	2,500,000	2,817,200
Steel	3,537,000	3,834,000	3,976,500
Ferro-alloys	250,000	243,000	264,300
Coal (total)	42,114,000	47,002,000	52,245,000
Hard coal	434,000	388,000	384,000
Brown coal	9,351,000	9,665,000	10,581,000
Lignite	32,309,000	36,949,000	41,279,000
Coke	2,486,000	2,628,000	2,693,000
Asbestos	10,041	12,106	13,391
Cement	9,021,000	9,315,600	9,779,000
Magnesite	293,000	252,000	300,000
Magnesite calcined	156,000	—	—
Salt	350,000	377,000	418,500
Fireclay	170,800	202,000	182,000

1. Kilograms. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric ton. N.A. Not available.

The Blagodat mine is in southeast Serbia, about 40 kilometers (25 miles) from Vanje on the slopes of Mount Besna Kobila. Annual production is 300,000 tons of ore, yielding 9,600 tons of lead concentrate and 12,670 tons of zinc concentrate. The ore is polymetallic, containing lead, zinc, gold, and cadmium. The mine, opened in 1974, is served by a 400-meter (1,312-foot) shaft and an adit some 7,000 meters (22,966 feet) long. It has been developed with five production levels, at 50-meter (164-foot) vertical intervals.

The flotation plant and other facilities were designed for a mine output of 350,000 tons per year. However, future development will raise production to 500,000 tons through extraction from new mining areas.

There are a number of important lead-zinc mines located relatively close to Skopje. Sasa, 150 kilometers (93 miles) away in eastern Macedonia, is the only deposit of the Sasa-Toranica ore-bearing zone currently being worked. This zone is a southeastern continuation of the Blagodat zone. Sasa mine was originally opened in 1966 at a production rate of 300,000 tons of ore per year. This was subsequently raised to 500,000 tons and is soon to be increased to 1,000,000 tons. Mining is by sub-level open stoping and caving. Concentrate production is 50,000 tons per year, containing 35 percent lead, 25 percent zinc, and 250 grams (8 ounces) of silver per ton.

The Toranica mine is situated 120 kilometers (75 miles) from Skopje in northeastern Macedonia. Basic mineralization is comprised of galena, sphalerite, and pyrite, with lesser quantities of chalcopyrite. The average grades are 4.5 percent Pb, 2.8 percent Zn, and 28 grams (0.9 ounce) of silver per ton. Development of the mine began in 1981; full production is scheduled for 1985, at a design output of 700,000 tons of ore per year. The resource potential of the Toranica ore field is reported to be high, and intense exploration of the surrounding area is continuing.

The Zletovo mining company operates about 100 kilometers (62 miles) to the east of Skopje. The mine is working the Dobrevo vein deposit. Underground mining, using shrinkage stoping and cut-and-fill, yields 500,000 tons of ore per year.

Yugoslavian production of ores in metric tons

Commodity	1979	1980	1981
Iron ore	4,617,000	4,530,000	N.A.
Copper ore	16,446,000	19,559,000	18,337,000
Lead-zinc ore	4,155,000	4,284,000	4,365,000
Bauxite	3,012,000	3,138,000	3,249,000
Pyrite concentrate	—	522,000	618,000
Manganese ore	32,320	36,400	33,400
Chrome ore	2,820	3,070	—
Antimony ore	91,000	70,000	66,000

1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric tons. N.A. Not Available.

The Vareš area is about 50 kilometers (30 miles) by road to the north of Sarajevo. The lenticular ore bodies contain as much as 80 percent $BaSO_4$ and 10 percent lead and zinc. The overall grade has been calculated at 0.8 percent Pb, 1.5 percent Zn, 20 percent $BaSO_4$, and 60 grams (1.9 ounces) of gold per ton. Iron ore has been mined from this ore field for many years, at the mines of Smreka, Droškovac, Brezik, and Pržići, at a total rate of over 2,000,000 tons of ore per year.

The base metal ore in the area is of a type not mined in Yugoslavia before. Intense geological and mining exploration was carried out between 1967 and 1971. As a result, construction of facilities began in 1978 and trial start-up of the flotation plant was scheduled for 1982. Overburden stripping at the Veovača mine was mostly completed in 1981. Processing will yield four concentrates: lead, zinc, barite, and pyrite. The ore body has also been reported to contain 0.25 percent antimony.

On the bank of the River Drina, some 200 kilometers southwest of Belgrade, is the Veliki Majdan mine. The deposit consists of a large number of small, but high-grade ore bodies, with surface areas ranging from 10 to 200 square meters (108 to 2,153 square feet). Mining from underground began in 1952. The flotation plant was modernized recently, in 1980, bringing recoveries up to 90 percent for lead, 85 percent for zinc, 80 percent for copper, 80 percent for silver, 80 percent for cadmium, and 70 percent for pyrite.

About 60,000 tons of ore are produced annually, with head grades of 3.5 percent Pb, 2.4 percent Zn, 0.4 percent Cu, 160 grams (5.1 ounces) of gold per ton, and 200 grams (6.4 ounces) of cadmium per ton. The mine is completing extensive exploration to extend its resource base, in order to double annual ore production.

Antimony

Deposits and occurrences of antimony in the country are numerous. The sole producer in the country, Rudarsko-Topioničarski Basen Zajača (RTB Zajača), is important by world standards. The Rajićeva Gora mine and the latest, Rujevac mine, developed in 1981, have a combined output of 120,000 tons of ore containing, on average, 2 to 3 percent

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Sb. At Rujevac, the ore also contains 0.5 to 2.2 percent As, 0.2 to 0.8 percent Pb, and 0.5 to 0.6 percent Zn. The smelter at Zajača has an annual capacity of 4,000 tons of metal. At present, a hydrometallurgical circuit to produce antimony from complex polymetallic concentrates is being introduced.

There are other antimony deposits, including those of Lojane, close to Kumanovo, and Alšar, 5 kilometers (3 miles) from the Yugoslav-Greek border. The Lojane ore contains 3 to 5 percent Sb, 4 to 6 percent As, 0.2 to 0.4 percent Ni, and low concentrations of uranium. The Alšar deposit is thought to be unique, containing antimony, arsenic, and titanium minerals in highly silicified dolomite. It grades 2 to 4 percent Sb and 1 percent As.

Chromite

The largest Yugoslav chromite deposit is Nada, in the Ljuboten magmatic complex. By 1978, over 1,200,000 tons of high-grade ore had been extracted. The ore is mostly friable, containing over 48 percent Cr_2O_3.

The Ulcinj Beach deposit is of interest. Here the chrome occurs with titaniferous magnetite, magnetite, ilmenite, and rutile. The sand contains over 1 percent chromite, 1.5 percent magnetite, and about 1.5 percent titaniferous magnetite. The beach is over 5 kilometers (3 miles) long and contains considerable reserves of chromite.

Chromite was mined at the Deva mine in Kosovo, but mining has currently been suspended due to the low grade of the deposit. In 1978 its reserves were estimated at 300,000 tons, mostly over 44 percent Cr_2O_3. However, exploration continues.

Mining of chromite has been conducted since 1880, producing between 10,000 and 125,000 tons of ore annually. During the late 1970's there was a steady decline in output and, by 1980, production was just 3,000 tons.

Nickel

Nickel mining is new to Yugoslavia. The Ržanovo mine came back into production in 1981. The mine, 40 kilometers (25 miles) from Kavadarci, extracts nickel-bearing laterite with an average content of 1.03 percent Ni. The annual output of this open pit is 2,300,000 tons. The ore is supplied to the new FENI ferro-nickel plant in Kavadarci. The smelter's design capacity is 22,000 tons of ferro-nickel per year.

The mines of Glavica and Čikatovo, located 20 and 40 kilometers (12.4 and 24.8 miles) to the west of Priština, respectively, have just been brought into production in 1982. The combined annual output is planned to be 983,000 tons of dry ore containing 1.32 percent Ni and 0.07 percent Co. Combined reserves were estimated in 1978 to be 26,700,000 tons.

A smelter is being built near the Čikatovo mine, scheduled for production at the beginning of 1983. The smelter production will be 52,160 tons of ferro-nickel each year, containing 23 percent Ni and 25 percent Co. ■

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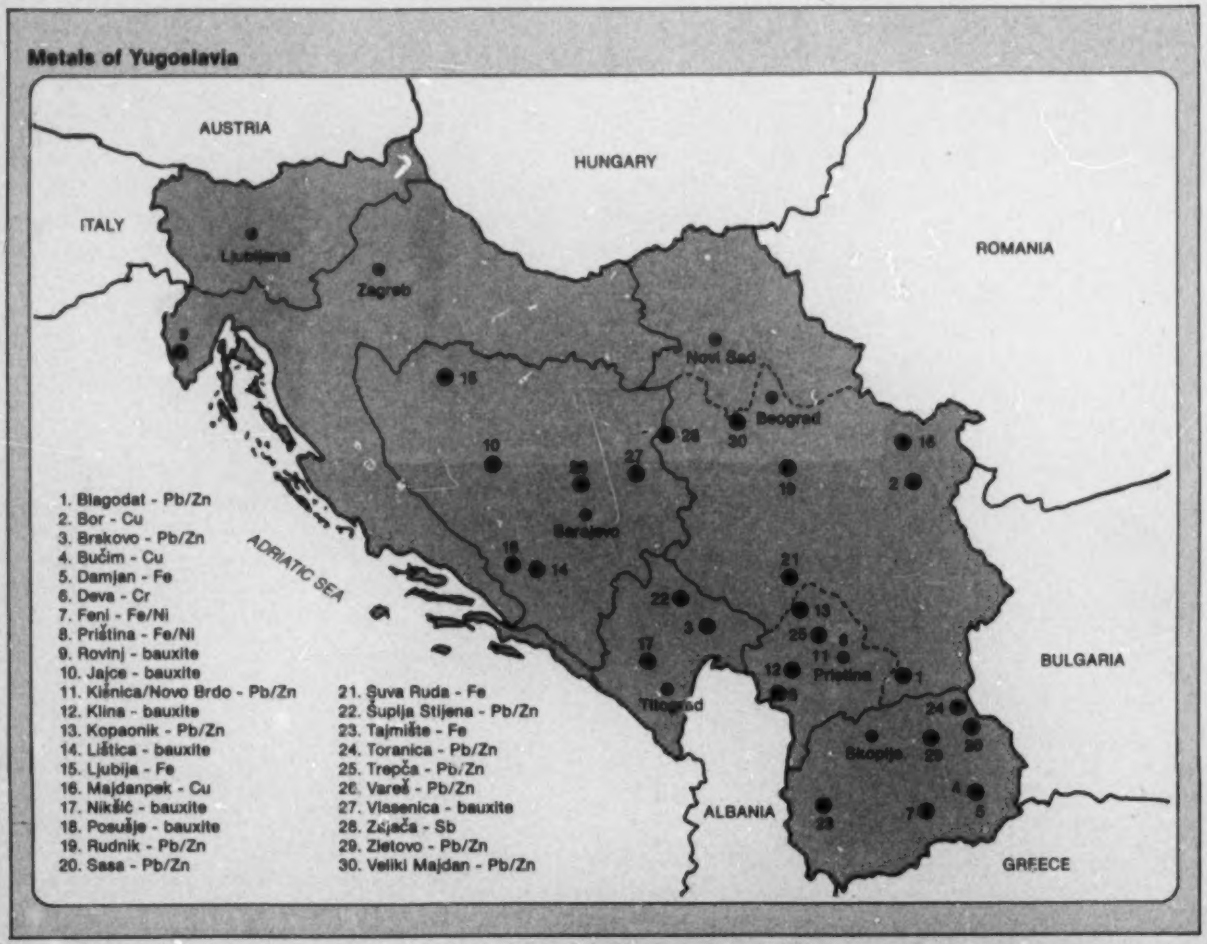

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After THOUGHTS

Mining engineers are cautiously predicting that Chile will replace the United States as the world's largest producer of copper in 1982. They also foresee a record production of molybdenum of about 50,000,000 pounds. It was an all-time high of 33,868,000 pounds in 1981.

Chile's production of copper will continue to increase. As one example, the Andina division of Corporación Nacional del Cobre de Chile is scheduled to virtually double copper production, reaching a level of 90,000 to 100,000 tons per year. Morrison-Knudsen Company, of Boise, Idaho, United States, which drove the long ore conveyor adit and built the underground Andina mill, has been retained to make a feasibility study of expansion. Other United States consulting engineering companies have also made similar studies.

These studies include increasing capacity of the underground mill as well as grinding ore from a new open pit high on the top of the mountain where the ore crops out under a glacier and conveying the slurry down the valley to a new mill, which would be built at the present concentrate and filtering plant. This would be a summer time only operation at that high altitude. So there has been discussion about stockpiling the pit ore in summer for milling in winter.

Recent Andina exploration has located a near surface ore body under a glacier with grades reported to be over 2.0 percent copper. This ore, when mined, will be an important source for increasing Andina's total production.

This new discovery is close to the property line of Compania Minera Disputada de las Condes and gives credibility to the growing idea that the mines are mining different sections of what is the same ore body on different sides of the mountain. There is no question but that the ore has a common source. While mineralization is not continuous between the mines, the recent discovery closes the mineralization gap between the two mines.

With Climax Molybdenum Company operating the Climax and Henderson mines so intermittently, with complete shut downs over long periods this year, Climax Molybdenum will produce only about 20,600,000 pounds pounds in 1982. In fact, both the Climax mine, which produced 49,824,000 pounds in 1981, and the Henderson mine, which produced 40,500,000 pounds of molybdenum last year, were closed on October 3, 1982 with no plans to produce any more molybdenum until 1983. Henderson production in 1982 totalled 18,400,000 pounds.

If Corporación del Cobre achieves the 50,000,000-pound production level this year it will be the largest molybdenum producer in the world, for one year, for the first time ever. It will also be the first year since 1915 that Climax was not the world's largest molybdenum producer.

It seems very safe to predict that Chile will supplant the United States as the world's largest copper producer this year for the first time. Again, the United States has been the largest producer for over 50 years. In fact, some engineers in Chile boast that that country will produce twice as much newly mined copper as the United States this year.

It now looks impossible for Chile to produce twice as much copper as the United States, but if Chile does reach the predicted output, it will lead. Despite all the mine closures in the United States, copper mine production was down only 126,370 tons in the first six months compared with the 1981 rate. The monthly average was 117,138 tons. However, there was a decline in the rate of production in both May and June based on the latest available figures from the United States Bureau of Mines, which listed May output at 106,720 tons and June at 99,090 tons. Note that the six-month figure includes these two months, so there was a steady decline in monthly output in the six months.

It looks as if Chile will supplant the United States as the world's largest copper producer this year

In fact, the United States copper production in the fourth quarter will possibly increase as Phelps Dodge Corporation, normally the second largest producer, resumes milling at the rate of 100,000 tons of ore per day at its Metcalf and Morenci pits.

At this writing Chile does not have a runaway lead in copper production, but an analysis of available production trends, admittedly from no recent data, indicates that it will lead by a short margin at the end of the year.

And it looks very strongly that Chile will be in a much better position to maintain, and perhaps increase, its lead in 1983.

All this proves that there is no substitute for high grade ore and strong governmental support for any segment of the mining industry. —*GOA*

World's top copper producers 1969-1981 (tons)

Year	United States	Chile	Zambia	Canada
1969	1,585,491	605,000	825,000	573,235
1970	1,719,657	594,724	682,727	672,717
1971	1,552,163	658,348	696,000	721,430
1972	1,642,704	661,875	761,002	793,303
1973	1,726,934	677,447	750,100	908,241
1974	1,593,580	996,200	780,428	928,551
1975	1,413,366	911,130	711,964	807,210
1976	1,605,586	1,105,859	782,840	804,020
1977	1,503,906	1,115,859	715,000	834,500
1978	1,358,000	1,134,913	659,802	723,273
1979	1,444,000	1,167,100	644,651	700,020
1980	1,488,428	1,179,400	670,929	779,257
1981	1,292,793	1,080,310	600,000	791,326

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Brazil tames the Amazon at Carajás 50

Botswana is becoming a leading diamond producer 64

World Mining

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JANUARY 1983

3rd World Mining PORPHYRY COPPER MAP is off the press

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JANUARY 1983
VOLUME 36, NO. 1

World Mining

THE COVER

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Brazil has begun a project to develop the virtually uninhabited jungle in the northeast Amazon and mine its huge reserves of iron ore, bauxite, copper, manganese, and gold

Brazil battles the jungle to mine Carajás minerals

Brazil has rather suddenly found itself the possessor of one of the richest mineral regions in the world. The iron ore deposits now being developed in the Carajás minerals province were found just 15 years ago. Since then, exploration has revealed an astonishing concentration and diversity of minerals covering a 4,000-square kilometer (1,544-square mile) area in the Amazon jungle.

Mineral reserves are presently estimated at 18,000,000,000 metric tons of iron ore, 4,648,000,000 tons of bauxite, 45,000,000 tons of potential manganese ore, 1,137,000,000 tons of potential copper ore, 40,140,000 tons of potential nickel ore, and 37,000 tons of potential tin ore. Further exploration is expected to raise these estimates to much higher levels than at present.

IRON ORE PROJECT in the Serra dos Carajás mountains will start up in 1985

Development of the reserves will be far from easy, both because of the massive amount of financing needed and the uninhabited location in the Amazon jungle. Brazil has estimated that the Grande Carajás project will cost around $60,000,000,000, which is about 75 percent of the country's foreign debt.

The Carajás project can best be described using three concentric circles, with the center being the location of the mineral deposits. The largest circle is Grande Carajás, which lies between the 8th parallel in the south, the Amazon and Xingu Rivers in the west, the Parnaíba River in the east, and the Atlantic Ocean in the north.

Grande Carajás comprises parts of three states—including Pará, Maranhão, and Goiás—about 10.6 percent of Brazil's total area. The region covers approximately 900,000 square kilometers (347,700 square miles) with a population of more than 7,000,000, about 6 percent of the population of Brazil. Although there are some small cities in Grande Carajás, there is little infrastructure. Ports, waterways, railroads, and highways must be developed so that production can move from the mines to markets and users. Power plants must be built to supply the mining projects with electricity.

The mineral resources of Grande Carajás lie in the Carajás minerals province, the center circle. The province covers a 4,000-square kilometer (1,544-square mile) area in southern Pará, in the southwest of Grande Carajás, and is bordered by the Araguaia and Tocantins Rivers in the east, the Xingu River in the west, the Serra do Bacajá mountains in the north, and the Serra dos Gradaús range in the south. The majority of the deposits in the province are within a 60-kilometer (37-mile) radius, the smallest of the three circles, in the Serra dos Carajás mountains.

The Carajás province is about 550 kilometers (345 miles) south of Belém and 780 kilometers (490 miles) southwest of São Luís. The nearest town to the province is Marabá on the Tocantins River. Marabá has a population of 31,000. The province itself has a population density of 0.7 inhabitant per square kilometer (1.8 per square mile).

Serra dos Carajás is a group of ridges rising 300 to 400 meters (984 to 1,312 feet) above the surrounding terrain and about 900 meters (2,953 feet) above sea level. About 90 percent of the annual precipitation occurs in the rainy season from November to May. Annual rainfall is 2,419 millimeters (95 inches). The province is covered with equatorial forest and occasional patches of low, sparse underbrush called "canga", which is an indication of underlying iron ore.

By **Regina Starr Ridley**
News Editor
Albert F. Kaba
Assistant Editor
Latin American Mining Letter

It was one of these canga-covered areas that set the Carajás project in motion in 1967. United States Steel Corporation was exploring for manganese in the Serra dos Carajás region. A company geologist was forced to make an emergency helicopter landing and found himself on top of a hill later discovered to contain 18,000,000,000 tons of hematite. Ten years later U. S. Steel sold its 50 percent share of the deposit to the state-owned Companhia Vale do Rio Doce (CVRD) for $50,000,000. The Carajás iron ore deposits will be the first mineral deposits to be developed in the Grande Carajás project.

Foreign companies involved in exploration in the Amazon region have generally shied away from large-scale investments. Two reasons for their reluctance appear to be the massive infrastructure requirements and the magnitude of the investments needed. The Brazilian government, through the CVRD, has moved in and taken over total responsibility for developing the necessary infrastructure. Construction of railroads and ports is already in progress. The government of Brazil has begun a publicity campaign to further stimulate the interest of foreign investors.

Evidence of Brazil's drive for investors was a seminar held in New York, New York on September 10, co-sponsored by Banco Itaú, a large Brazilian bank, and by the Brazilian-American Chamber of Commerce. Speakers included Dr. Nestor Jost, chief executive officer of the Interministerial Council on the Grande Carajás Project; Samir Zraick, director of finance of CVRD; Ernane Galvêas, minister of finance of Brazil; and Olavo Setubal, chairman and president of Banco Itaú.

All speakers stressed Brazil's strong commitment to Carajás and the need for foreign participation. "We know that purely national (financial) resources, however vast they may be, are simply not sufficient to cover our needs," said Setubal. It is known that preference will be given to domestic firms over foreign companies. However, it is also apparent that investment by foreign companies and international organizations is absolutely necessary for the project to move ahead.

Table 1.
Financing for Carajás iron ore project

Source	Amount of Loan (multiply by $1,000,000)
European Economic Community	600
Consortium of Japanese banks	500
World Bank	304.5
Rehabilitation Bank (West Germany)	122.5
Morgan Guaranty Trust (United States) and Dresdner Bank (West Germany)	100
United States Export-Import Bank	68
Other	75
Total foreign financing	**1,770**
Companhia Vale do Rio Doce	852
Banco Nacional do Desenvolvimento Econômico y Social	1,020
Total Brazilian funding	**1,872**
Total financing	**3,642**

A $4,900,000,000 Iron Ore Project

The government selected deposits in the Serra dos Carajás to be the first at Grande Carajás to be developed, because of their high natural iron ore content. The project should provide early cash flow, and a surge in iron ore demand is expected in 1985 when it is scheduled to start up. CVRD has been granted the rights to mine the 18,000,000,000 tons of ore, grading 66 percent iron.

Total cost of the project is estimated at $4,900,000,000. CVRD has arranged financing for $3,640,000,000, evenly divided among foreign and Brazilian sources (see Table 1).

No concentration or treatment of the high-grade ore is required, other than simple reduction of the run-of-mine ore to sinter feed and natural pellets by successive crushing, screening, and solids recovery methods. Production is anticipated at 10,000,000 tons of iron ore per year by 1985 and 25,000,000 tons by 1986, rising to 35,000,000 tons in 1988, with approximately 85 percent of output in the form of sinter-feed and the rest in pellets. Future expansion may boost production to 50,000,000 tons per year.

Initial development of the project has already begun. A pilot plant has been built and is now in operation. Construction work has also begun on a beneficiation plant. International consumers are so confident about the project that CVRD has signed contracts for the sale of 26,000,000 tons of iron ore for delivery after 1985 to Japan, West Germany, France, Italy, South Korea, and Taiwan.

The iron ore of Carajás has been classified into four groups: Serra Norte, Serra Sul, Serra Leste, and São Felix. The first three groups are contained in the 60-kilometer (37-mile) radius of the Carajás province. Most of the Serra dos Carajás iron ore deposits are located along two flanks—Serra Norte and Serra Sul—about 35 kilometers (22 miles) apart. Mining will start in 1985 in the N4E ore body, which is located in Serra Norte. (For the geology of the iron ore and other mineral deposits in Grande Carajás, see the box on page 57.)

N4E is a J-shaped ore body measuring 4.2 kilometers (2.6 miles) in length. N4E was mapped by 1,540 meters (5,053 feet) of tunnels and 20,100 meters (65,948 feet) of drill holes. About 49,000 assays on drill-core samples were performed at 3-meter (10-foot) intervals and 750 different physical tests were completed.

The deposit will be developed as an open pit mine with 15-meter (49-foot) high benches. The mining plan is based on a waste-to-ore ratio of 0.235 to 1 and a total of 1,216,000,000 tons of ore in the deposit. Electric-powered rotary drills, 9⅞ inches in diameter, will be used for conventional blasthole drilling.

The ore will be loaded by 16-cubic yard (12.2-cubic meter) electric shovels, then hauled in 154-ton (170-short ton) trucks. Front-end loaders with an 11-cubic yard (8.4-cubic meter) bucket capacity will assist in loading and blending the ore. Mining is scheduled for 303 days per year, three shifts per day.

Off-highway trucks will transport the ore to the beneficiation plant adjacent to N4E ore body. The plant has been designed in modular form to allow for future expansion. The ore will be transported by rail from the plant to the loading port at Ponta da Madeira on São Luís Island, which will be able to handle vessels from 20,000 to 280,000 deadweight tons at one berth equipped with a double-boom linear shiploader. Each boom will load 16,000 tons per hour.

The Amazon Factor

Carajás is the third project to battle the formidable jungle forces known as the "Amazon factor." (First was Henry Ford with Fordlandia in the 1920's, then Daniel K. Ludwig with the Jari Project in the 1960's and 1970's.) The Amazon factor is the combination of unfavorable climatic conditions, scarcity of local manpower, and the tremendous geographic distances in the jungle. Perhaps the myth of the untamable Amazon jungle will come to an end with the Grande Carajás project.

The transportation backbone of the Grande Carajás program will be an 890-kilometer (553-mile) long railway connecting Serra dos Carajás and the Ponta da Madeira port, which will handle the bulk of iron ore shipments. About 11 kilometers (7 miles) of bridges and viaducts will be constructed, but no tunnels need to be driven. A 2.4-kilometer (1.5-mile) long bridge, supported by 20-meter (60-foot) high concrete pillars, will stretch across the Tocantins River. A 150-kilometer (93-mile) long branch of the railway will link the Paragominas bauxite deposits with the main rail line.

The railroad system will have 57 locomotives and 3,077 cars. Iron ore handling capacity is estimated to be about 35,000,000 tons per year.

Two major highways, Belém-Brasília and Transamazônica, already connect the north, center, and south of Brazil with the city of Marabá, about 200 kilometers (124 miles) northeast of the Serra dos Carajás mountains. However, the Transamazônica has been plagued with problems since the start of the project in 1973 and has been nicknamed "Transamargura", which translates to "road to bitterness".

An iron ore stockpile area with a 3,600,000-ton capacity will be built at the terminal at Ponta da Madeira. A sampling station and two high precision scales will be installed between the stockpile area and the shiploading facilities.

A secondary transportation system for Carajás iron ore will be the Tocantins River, which connects the deposits to the port of Vila do Conde in Barcarena. Scheduled for completion in mid-1984, Vila do Conde will load vessels of up to 60,000 deadweight tons and will also be an important export terminal for alumina and aluminum. Aside from the ports at Ponta da Madeira and Vila do Conde, a third port, Itaqui, located 15 kilometers (9 miles) from São Luís on São Marcos Bay, will handle vessels of up to 60,000 deadweight tons.

The major source of electricity for the Carajás project is the Tucuruí hydroelectric plant on the Tocantins River, about 300 kilometers (186 miles) south of Belém. The $7,100,000 plant is scheduled for completion in 1983-84. Initial capacity will be 3,960 megawatts, to be eventually raised to 7,920 megawatts.

Other hydroelectric plants will be built in Santa Isabel on the Araguaia

River and in Santo Antonio and Carolina on the Tocantins. The combined generating potential of the Araguaia, Tocantins, and Xingu rivers in the Carajás province is 35,000 megawatts, equal to all of Brazil's presently installed electric power.

CVRD has divided Grande Carajás into seven industrial districts and urban centers: Tucuruí, Belém, São Luís, Marabá, Carajás, São Félix, and Imperatriz. CVRD will provide basic services such as housing, education, health, and recreation. The construction of houses, schools, and hospitals has recently been accelerated to accommodaté the large influx of people seeking jobs in the Grande Carajás project.

To facilitate access to the region, two asphalt airstrips, which are capable of handling large airplanes, have been constructed at Tucuruí and Serra dos Carajás. The cities of Marabá and Imperatriz already have airports serving scheduled airlines.

Integrated System Planned

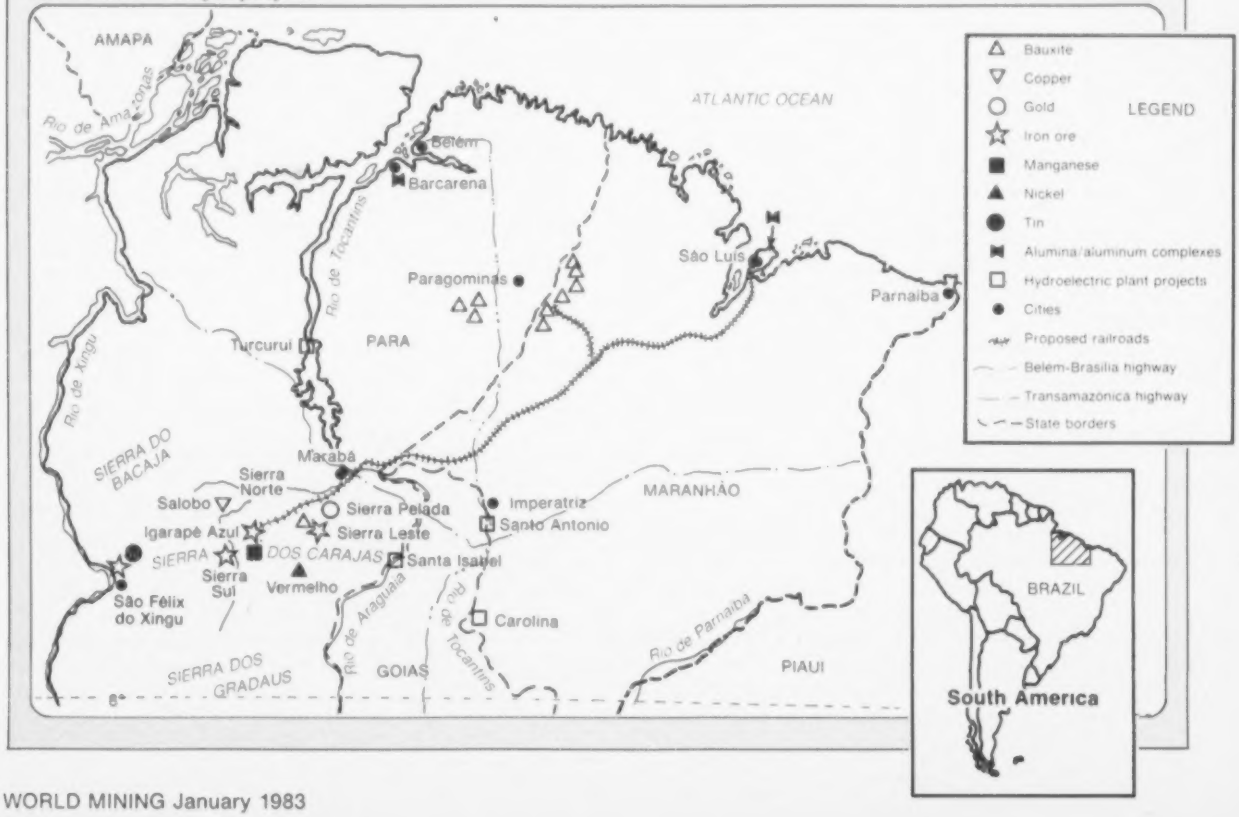
An integrated system has been designed for the production and transportation of bauxite-alumina-and aluminum in Grande Carajás. Current reserve estimates of 4,700,000,000 tons of bauxite give Brazil the third largest bauxite reserves in the world. Most of Brazil's bauxite deposits are located in Grande Carajás (Paragominas and Serra dos Carajás) and the eastern Amazon region just west of Grande Carajás (Trombetas and Almeirim):

- Paragominas: The reserves at Paragominas, the largest group of known bauxite deposits in Brazil, are estimated at 2,400,000,000 tons with an average grade of 50 percent available alumina and 4.5 percent of reactive silica. Paragominas is in Pará and Maranhão, about 400 kilometers (250 miles) northeast of Serra dos Carajás. The ore is extremely favorable to the production of alumina.
- Trombetas: At 1,700,000,000 tons, with grades and characteristics similar to the Paragominas deposits, Trombetas is Brazil's second largest known deposit. It is located on the banks of the Trombetas River, approximately 900 kilometers (560 miles) west of Barcarena and Belém. Mineração Rio do Norte (MRN), 46-percent owned by CVRD, operates the Trombetas mine and is already producing 3,400,000 tons of ore per year. MRN's expansion plans call for an increase to 6,700,000 tons of bauxite per year.
- Almeirim: These deposits are located downstream from Trombetas on the Amazon River, and contain an estimated 500,000,000 tons of bauxite with available alumina and reactive silica. The deposits have an extremely low iron grade, but are adequate for the production of alumina and may be used in the refractory industry.
- Serra dos Carajás: Some 120 sample pits have proven a crude ore reserve of 48,000,000 tons of bauxite, with grades of 35 percent of available Al_2O_3, 1 to 7 percent of SiO_2, 25 percent of Fe_2O_3, and 40 percent of TiO_2. Mining operations are expected to be relatively easy for this deposit since it is located only 2 kilometers (1.2 miles) from the site of the future railroad terminal. Preliminary investigations have indicated that the ore body is only 5 meters (16 feet) below the surface.

The bauxite in Trombetas and Paragominas is planned to supply the Aluminio Brasileiro S. A. (Albrás) and Alumina do Norte Brasil S. A. (Alunorte) refinery/smelter project in Barcarena. Electricity will be provided by the Tucuruí hydroelectric plant. Albrás/Alunorte is a $2,600,000,000 joint venture between CVRD and Nippon Amazon Aluminum Company (Nalco), a consortium of five Japanese companies. The project has recently been renamed Consorcio de Construção Albrás/Alunorte (Consoal).

The Alunorte refinery is being designed for the production of 800,000 tons of alumina per year. Completion of the

The Grande Carajás project



Project Guidelines

At a recent seminar on the Carajás project, Alain Belda, president of Alcoa do Brasil, offered several guidelines for investors:

- Brazilianization: Ideally, the human resources should not only be Brazilian, but regional within Brazil. Brazilian personal and cultural traits must be taken into account and respected.
- Infrastructure: The lack of local infrastructure in northern Brazil, about 4,800 kilometers (2,983 miles) from the developed south, must be taken into account.
- Manpower: The investor must be aware of the relatively high cost of training new employees. Brazilian workers need extensive training to acquire skills needed for large projects and modern equipment operation.
- Exports: Projects that increase exports will be preferred. Fiscal incentives favor companies committed to export.
- Production goals: Projects should give considerable attention to achieving production of scale as soon as possible, to allow return on the very high costs of construction and initial stages of operation. Due to Brazil's protective import barriers, costs of domestically-built equipment tend to be high.
- Environment: National and multinational industries planning to invest in Carajás must include all necessary conservation precautions before securing the required construction and operation licenses.

refinery is expected by 1984. The alumina will primarily supply Albrás and CVRD's Valesul smelter in Santa Cruz near Rio de Janeiro. Half of the aluminum production from the two smelters will be earmarked for export and the rest will be used to meet domestic demand.

Production of 99.7 percent pure aluminum in ingot form at the Albrás smelter was originally scheduled to begin by mid-1984, but has been delayed one year. Initial annual capacity has been set at 80,000 tons, with expansion to 320,000 tons per year planned for late 1988.

Aluminio do Maranhão S. A.'s (Alumar) alumina-aluminum project on the island of São Luís represents the largest privately funded project (at a cost of $1,500,000,000) ever undertaken in Brazil. The refinery/smelter is scheduled for an initial production of 500,000 tons of alumina and 100,000 tons of aluminum per year beginning in July 1984. An annual production of 3,000,000 tons of alumina and 300,000 tons of aluminum is foreseen by 1990. A portion of the aluminum production will be exported.

Bauxite for the Alumar project will be supplied by MRN in Trombetas until bauxite mines are developed in Serra dos Carajás and Paragominas. Alumar is a $1,300,000,000 joint venture between Alcoa Aluminio do Brasil (60 percent) and Billiton International Metals B. V. (40 percent), the mining and metallurgical branch of the Royal Dutch Shell Petroleum group. At least 85 percent of the equipment required to build and operate the Alumar project will be Brazilian-manufactured, and about 98 percent of the manpower will be Brazilian, according to Alcoa Aluminio S. A. president Alain Belda.

Blue Creek Manganese Deposit

The most recent skirmish in Carajás was over the ownership of the largest manganese deposit in the Amazon, Igarapé Azul, which translates to "Blue Creek". CVRD and six private companies each presented proposals for the development of the deposit to the Interministerial Council. At first it appeared that private development would be chosen as the government had stated its goal of bringing in private investment, and CVRD was already heavily involved in the iron ore project.

On the other hand, CVRD had already spent an estimated $210,000,000 in research and equipment for the project. CVRD was also building the infrastructure that would be used to transport the manganese. After several delays, on September 22, 1982 the Interministerial Council selected CVRD to develop Igarapé Azul.

The Igarapé Azul deposit was found during a geological reconnaissance in September 1971. The deposit contains an estimated 45,000,000 tons of potential ore grading 42.2 percent manganese. Located about 10 kilometers (6 miles) south of the iron ore deposits at Serra Norte, Igarapé Azul is only 20 kilometers (12 miles) west of CVRD's iron ore pilot plant and the railroad terminal. The easy access to transportation makes Igarapé Azul the next site for development after the iron ore project.

The top zone of the manganese deposit contains about 16,300,000 tons of potential ore with an average grade of 42.64 percent manganese. The surface deposits are detrital ore, made up of pisolites, manganiferous breccia, boulders, and plates. After washing, the pisolites grade between 14 and 18 percent manganese, and are not considered to be economically recoverable. The manganiferous lateritic breccias have a manganese content between 24 and 46 percent. Boulders contain 48 to 54 percent manganese. The manganese content of the plates retained in an ¼-inch screen is from 40 to 50 percent.

A second zone in Igarapé Azul contains about 16,600,000 tons of pelitic and grained material averaging 38.96 percent manganese. The pelitic material will contain about 39 percent manganese after treatment. Grained material, having a manganese to iron ratio of 12 to 1 and containing an average of 46.4 percent manganese, has been tested for use in the dry battery industry, with promising results. The third zone, carbonate manganese protore, contains 11,400,000 tons of 46.36 percent manganese.

The two other manganese deposits in Carajás province, the only other Mn deposits in the entire Amazon, are Serra de Buritirama and Serra do Sereno. Serra de Buritirama contains 12,000,000 tons of potential ore grading 47 percent manganese, and is owned by Companhia Meridional de Mineracão, a subsidiary of United States Steel Corporation. Serra do Sereno is owned by CVRD and contains 3,000,000 tons of potential ore grading 40 percent manganese.

Preliminary plans for development of Igarapé Azul are for an annual production of 500,000 to 1,000,000 tons of ore beginning in 1985. About 75 percent of production will be retained for the domestic market; the remainder will be exported. Brazil's 1981 manganese ore production was 2,100,000 tons. About 1,200,000 tons were exported and some 800,000 tons were consumed domestically. Development of the deposit is expected to cost between $40,000,000 and $50,000,000.

Construction of a ferroalloy plant is planned. Output would initially be 150,000 tons of ferromanganese per year, mainly for export. Capacity could be expanded to 350,000 tons per year.

Copper for Domestic Demand

Until the start-up of the Caraíba Metais smelter/refinery in mid-1982, Brazil had no domestic refined copper production. Caraíba Metais has a capacity of 150,000 tons of refined copper per year. Brazil's demand for copper is expected to rise to 500,000 tons per year by 1990.

Because of the importance of limiting imports and maintaining a favorable balance of trade, development of copper deposits in the Carajás province has a high priority. The Interministerial Council has just authorized CVRD to look for private companies interested in developing the Salobo 3A deposit in Carajás. Mining and construction contracts may be awarded in 1983 or 1984.

Copper mineralization in the Carajás province was found in 1977 by a geological survey of stream sediment. Soil geochemical survey and terrain geophysical works indicated copper anomalies of great lateral extension. The first holes drilled in 1978 contained copper sulphides in schists with magnetite. The

140 meters (459 feet) of drill core had an average copper grade of 0.41 percent. Further exploration led to the delineation of the Salobo 3A copper deposit, located about 60 kilometers (37 miles) northwest of the railroad terminal.

Saloba 3A has estimated reserves of 1,137,000,000 tons of potential ore grading 0.83 percent copper. The deposit contains an estimated 469,900,000 tons of potential sulphide ore grading 1.28 percent copper, and 569,700,000 tons of potential sulphide ore grading 0.48 percent. The sulphide mineralization is bornite and chalcocite (80 to 85 percent). Small amounts of gold, silver, and molybdenite are associated with layers containing copper sulphides. Salobo 3A also contains 97,400,000 tons of altered material grading 0.77 percent copper.

Preliminary development plans for the Salobo 3A deposit call for production of 32 percent copper concentrate and recovery of gold as a byproduct. Half of the output will go to existing Brazilian companies and half to plants that are planned to be built in the region.

Gold Rush at Serra Pelada

Recent huge gold nugget discoveries have thrust Carajás gold resources into international news. The most active location for gold prospecting is at Serra Pelada, a large "garimpo", or alluvial gold deposit. The gold at Serra Pelada is mined by "garimpeiros", independent gold prospectors. Serra Pelada is about 90 kilometers (56 miles) south of Marabá, and adjacent to the Serra Leste iron ore deposits.

About 30,000 garimpeiros work in the Serra Pelada pit, which is 76 meters (250 feet) deep, more than ¼ kilometer (½ mile) long, and almost ½ kilometer (¼ mile) wide. The mine has no machinery: men use picks and shovels, and carry sacks of soil up ladders to the top of the pit for sifting and washing. The government grants garimpeiros a 5-meter (55-foot) square plot and allows each to have nine workers. All gold recovered must be sold to the state bank.

The garimpeiros are recovering gold from an ore body and from ferruginous laterite at the north end of the primary deposit. Average gold content in the laterite is 0.096 ounce per cubic meter (0.12 ounce per cubic yard). Three types of gold are mined at Serra Pelada: yellow gold with 1 to 2 percent palladium, white gold with 6 to 7 percent palladium, and black gold with a palladium content of 9 to 10 percent.

Garimpeiros at Serra Pelada, the largest known garimpo in Brazil, have mined 450,100 ounces of gold since the deposit was discovered about four years ago. At this point, the gold resources of Carajás have not been estimated.

Twin Nickel Deposits at Vermelho

CVRD's geological survey of the Carajás province indicated 40,140,000 tons of laterite grading 1.56 percent nickel at Vermelho I and II, about 50 kilometers (31 miles) southeast of the railroad terminal. The Vermelho deposits contain an estimated 20,190,000 tons of potential garnieritic ore grading 1.99 percent nickel and 19,950,000 tons of potential oxidized ore grading 1.12 percent nickel.

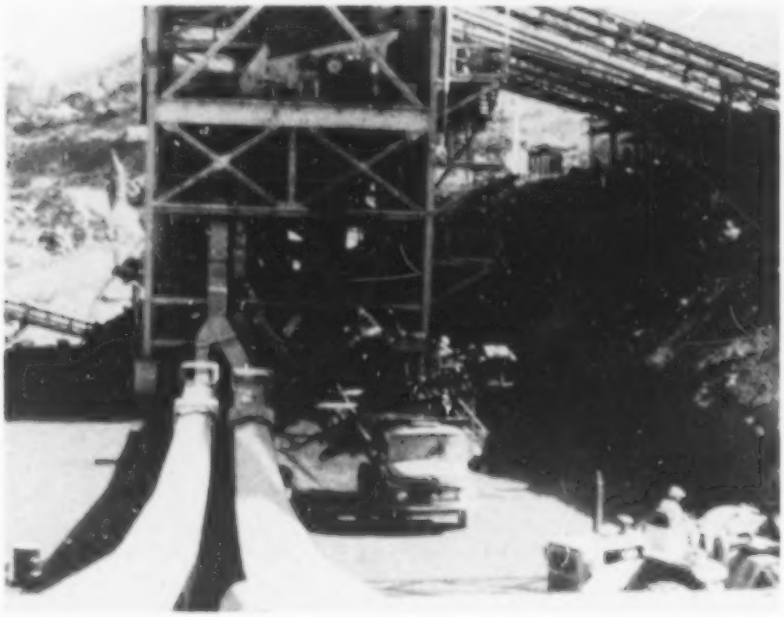
Initial nickel production will be shipped to domestic markets. Output is now planned at 1,660,000 tons of ore per year with an eventual expansion to 2,490,000 tons per year. Nickel refining capacity would start at 20,000 tons of nickel per year, with a projected expansion to 30,000 tons per year. The higher rates of production depend upon positive results from further exploration for nickel in the area. Although no other deposits have been delineated, exploration has shown indications of promising nickel mineralization.

Cassiterite and Wolframite

Granitoid instrusive suites containing both cassiterite and wolframite mineralization have been found in the São Felix do Xingu region. CVRD estimates tin reserves at 37,000 tons in alluvial placers.

The alkaline granites in the region show promising occurrences of wolframite, although a reserve estimate has not yet been made. During 1981 garimpeiros recovered 527 tons of wolframite, and production last year is believed to have been even higher.

FUTURE PORT at Ponta da Madeira in São Luis, currently under construction, will handle most iron ore shipments and accommodate vessels of 280,000 deadweight tons.



CRUSHING PLANT will reduce Carajás iron ore for the production of sinter and pellets.

Non-mineral Resources

The lush forests of the Amazon jungle are a major non-mineral resource of Grande Carajás. The wood is in strong demand domestically both as an industrial raw material and for wood charcoal. According to government estimates, the present supply of wood in Grande Carajás could produce the charcoal equivalent to 12,000 barrels of oil per day for 3,500 years. A $1,300,000,000 project under consideration calls for the reforestation of a 5,900,000-acre area.

An important energy resource in Grande Carajás is the Amazon River. Centrais Eléctricas Brasileiras S. A. (Electrobrás) estimates the hydroelectric potential of the River at 70,000 megawatts, much of which will be used for Grande Carajás projects.

The Last Frontier

The high degree of "Brazilianization" sought in the Grande Carajás project is clear evidence of Brazil's desire to use domestic production and resources as much as possible. The climate in Brazil for foreign-based companies interested in Carajás mineral resources can best be described as cautious, but welcoming.

According to Belda, Brazilians tend to look at multinationals as "needed, but not beloved," and they would rather keep all profitable activities in the hands of Brazilians. However, they do accept that foreign capital is absolutely necessary to meet Brazil's growing industrialization. With the exception of limited areas considered vital to security, both national and multinational companies are welcome to invest in all areas of the economy.

"The appropriate capitalization model (for Grande Carajás) should seek to equilibrate three alternative sources of funds: Brazilian capital, foreign capital, and financing supported by the Brazilian government and by local banks," explained Olavo E. Setubal, chairman and president of Banco Itaú.

The Brazilian government claims that it plans no further direct financial involvement in Carajás. Incentives will be granted and the risks left to the entrepreneurs. One incentive that the Interministerial Council has offered is to exempt foreign investors from paying income tax for 10 years, provided the initial investment is made before December 31, 1983, and the investor finances the development of other Carajás projects. Cost preference on bids is given to Brazilian equipment suppliers.

The Interministerial Council has also touched upon several non-mining controversies: the environment and the Amazon Indians. Environmental concerns are relatively new in Brazil. Many ecologists are deeply worried about the environmental effects of the Grande Carajás program.

The government has proposed that smelters and other industrial projects be fueled with charcoal made by stripping and burning wood from the Amazon jungle. Many scientists are concerned that only a part of the soil will regenerate timber and vegetation. They fear that clearing the jungle would create a climatic disaster.

Banco Itaú has published scientific studies with warnings that indiscriminate clearing of the jungle could lead to erosion, lengthy droughts, and eventual transformation into arid steppes. Studies warn of flooding of the Amazon basin and climactic changes for large areas in South America. CVRD says it is already researching appropriate methods of harvesting Amazon timber and is developing plans for reforestation.

An anthropological controversy has arisen over the plight of Amazon Indians. The intrusion of twentieth century civilization and technology in the Amazon has threatened the lives and culture of Indian tribes, and brought in its wake

Table 2.
Mineral reserves in Grande Carajás

Mineral	Estimated reserves (million metric tons)	Deposits	Start-up date	Production rate (million metric tons per year)	Operator
Iron	18,000 66 percent Fe	Serra Norte, Serra Sul Serra Leste, São Felix	1985	10	CVRD
Bauxite	2,400 1,700	Paragominas Trombetas	—[4]	—[4]	—[4] Mineração Rio do Norte
	500 48 4,648	Almeiran Serra dos Carajás	—[4]	—[4]	—[4] —[4]
Manganese	45 42.2 percent Mn	Igarapé Azul	1985	.05	CVRD
Copper	1,137 0.83 percent Cu	Salobo 3A	1985 (?)	—[4]	—[4]
Gold	—[3]	Serra Palada[5]	—[4]	—[4]	—[2]
Nickel	40.14 1.56 percent Ni	Vermelho I and II	—[4]	1.66	—[4]
Tin	.037[7]	São Felix do Xingu region	—[4]	—[4]	—[4,6]
Tungsten	—[3]	São Felix do Xingu region	—[4]	—[4]	—[4,6]

1. Undetermined. 2. Some production by small miners. 3. Unquantified. 4. On-going. 5. And other alluvial deposits. 6. Unknown. 7. In alluvial placers.

a number of diseases against which the Indians lack immunity. Although the government has established an agency, Funai, to relocate the Indians and help preserve their cultures, mining interests are generally favored.

The main consideration in developing Carajás minerals will be how to best utilize Amazonian resources. The Grande Carajás program is considered a crucial means by which Brazil can realize its aspirations of becoming a fully developed country. Carajás and the greater Amazon region represent one of the world's few remaining frontiers. The program is a comprehensive plan for the development of the region.

If successful, Grande Carajás will help Brazil achieve and maintain a healthy balance of payments. The foreign debt now stands at a staggering $80,000,000,000 and financial credibility has suffered. Brazil hopes that its program will reverse the current situation. As the minister of finance, Ernane Galveas, said in his address to delegates at the seminar: "Carajás is not a dream, but a reality. It is a cornerstone in Brazil's essential plan to increase exports and decrease foreign debt." ■

Geology of Carajás Deposits

The N4E deposit, the first iron ore deposit to be mined in the Grande Carajás project, has three basic types of ore, classified by grain-size distribution: friable, hard, and soft hematite. Friable hematite makes up 84 percent of N4E's total ore reserves, is bluish to dark gray with millimetric banding, and is composed predominantly of ¼-inch to 60-mesh size material.

Bauxite in Serra dos Carajás is found in altered basaltic rock around the N5 Serra Norte iron deposit in the north-northeast extension of the N5 plateau. The deposits cover about 65 square kilometers (25 square miles), have a lateritic, blanket-type surface without waste overburden, and are a residual product of weathered mafic rock. Drill holes and pits indicate a well-defined rock sequence, from top to bottom:

- Earthy, ferruginous, friable bauxite containing a small percentage of ferruginous nodules and pisolites towards the bottom
- Ferruginous laterite — normally hard, and sometimes pisolitic
- Plastic reddish clay, probably an alteration product of the mafic rock.

The Igarapé Azul manganese deposit is in a basin drained by the Azul and Aguas Claras creeks. Surface deposits are detrital ore, composed of pisolites, manganiferous breccia, large boulders, and plates. Pisolites, locally dispersed and accumulated on the Paleozoic flanks, are composed of cryptomelane, birnessite, lithiophilite, gibbsite, kaolinite, and goethite.

The manganiferous lateritic breccias contain lithiophilite and cryptomelane cemented by goethite and gibbsite. The boulders' main component is cryptomelane, and the plates contain mostly lithiophilite and cryptomelane.

The second zone of Igarapé Azul is made up of underground deposits of weathered and enriched pelitic rocks, hard manganese material, and grained material. A third zone consists of carbonate manganese protore.

The Salobo 3A copper deposit is composed of metasedimentary rock with subordinate basic metavolcanic rock that may be lower Proterozoic. The stratiform deposit is surrounded by tonalitic gneisses and sericitic quartzites. From top to bottom, the Salobo sequence can be divided into five stratigraphic units: quartzite, upper gneiss, banded iron formation, schists, and lower gneiss.

The copper deposit shows lithologic control as the copper sulphides are associated with schists containing magnetite, amphibole, garnet, olivine, and biotite. An interesting feature of the deposit is the absence of copper minerals typical to oxidation zones. Weathered schists and gneisses, which are altered supergene material, do not contain such secondary minerals as azurite, malachite, or chrysocolla.

Serra Pelada garimpo, an alluvial gold deposit, is considered typical of other placer gold deposits in the area. Gold occurrences in Carajás are usually associated with metasedimentary-volcanogenic sequences, appearing in quartz veins, in metachert bodies, or in stratiform sulphide deposits, with intercalated sulphide horizons in a sequence of chlorite schists, or in metapelitic rocks associated with acid volcanics. The geology of the gold occurrences suggests the existence of a greenstone belt in Carajás.

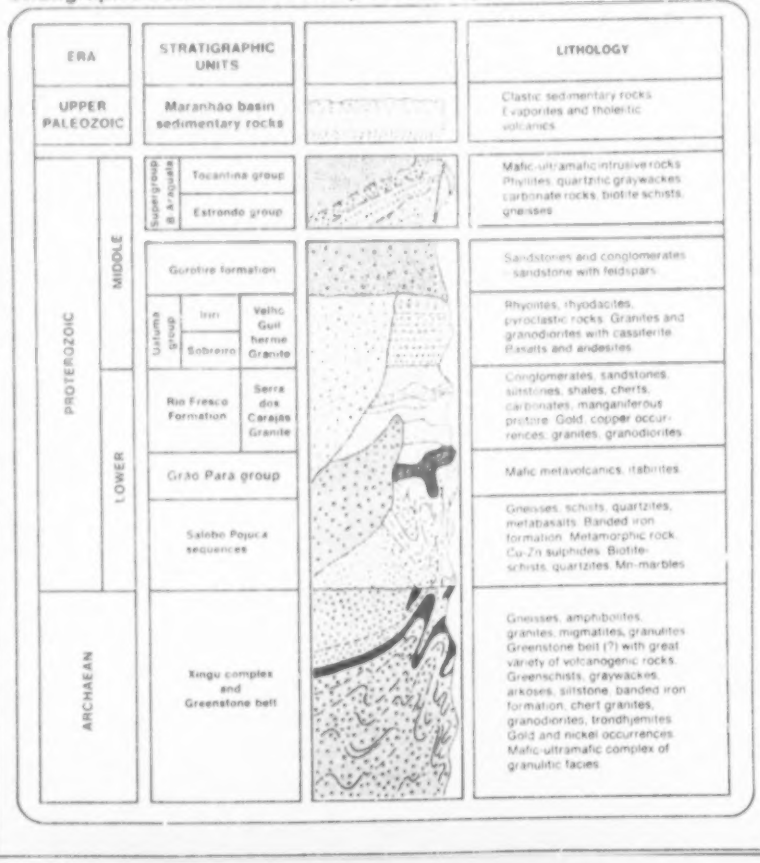
The gold deposits have lithologic, tectonic, and structural control. Most of the gold concentration is in siltstone units, in manganiferous breccia, and at the grey/red siltstone interface. The gold is also related to hinge folding and faulting zones.

The nickel deposits, Vermelho I and II, are located in two elongated hills. The hill tops are capped by a resistant layer of iron-silica laterite. The mafic-ultramafic hills include the following types of rocks: gabbros, metagabbros, norites, piroxinetes, serpentinites, and peridotites and dunites altered to silcrete.

The four zones of the laterite profile, from top to bottom, are: laterite, clay, saprolite, and serpentinite.

The laterite zone has ferruginous material and is red, brown, yellow, yellow-brown or red-brown in color according to the goethite or hematite contents. The clay zone contains blocks of silcrete and veins of silica which have boxwork structures.

Stratigraphic column of the Carajás mineral province — Figure 1


ERA
STRATIGRAPHIC UNITS
LITHOLOGY
UPPER PALEOZOIC
Maranhão basin sedimentary rocks
Clastic sedimentary rocks. Evaporites and tholeiitic volcanics.
PROTEROZOIC
MIDDLE
LOWER
Supergroup Araquaia
Tocantina group
Estrondo group
Mafic-ultramafic intrusive rocks. Phyllites, quartzitic graywackes, carbonate rocks, biotite schists, gneisses
Gurotire formation
Sandstones and conglomerates; sandstone with feldspars
Uatuma group
Iriri
Sobreiro
Velho Guilherme Granite
Rhyolites, rhyodacites, pyroclastic rocks. Granites and granodiorites with cassiterite. Basalts and andesites
Rio Fresco Formation
Serra dos Carajás Granite
Conglomerates, sandstones, siltstones, shales, cherts, carbonates, manganiferous protore. Gold, copper occurrences; granites, granodiorites
Grao Para group
Mafic metavolcanics, itabirites
Salobo Pojuca sequences
Gneisses, schists, quartzites, metabasalts. Banded iron formation. Metamorphic rock. Cu-Zn sulphides. Biotite-schists, quartzites. Mn-marbles
ARCHAEAN
Xingu complex and Greenstone belt
Gneisses, amphibolites, granites, migmatites, granulites. Greenstone belt (?) with great variety of volcanogenic rocks. Greenschists, graywackes, arkoses, siltstone, banded iron formation, chert granites, granodiorites, trondhjemites. Gold and nickel occurrences. Mafic-ultramafic complex of granulitic facies

BEST AVAILABLE COPY

Once Jwaneng is producing to capacity, by 1985, Botswana's output from its three mines will put it among the leading producers of gem diamonds in the world. Total output of all grades will be some 9,500,000 carats

Jwaneng and Botswana: at height of diamond production

By **John R. Chadwick**
Senior Technical Editor

During the 1981 financial year, the diamonds that had been mined by the De Beers Botswana Mining Company (Pty) Ltd. (Debswana) accounted for about a third of the government's revenue and provided 61 percent ($150,000,000) of Botswana's foreign income. During that same period, Jwaneng was not in commercial production. It has now begun operations and should produce about 2,500,000 carats in 1982. As the feed grade improves, the mine's output will rise progressively to about 4,500,000 carats by 1985. At that time, the country's total caratage will be some 9,500,000 per year.

Thus, diamonds are of prime importance to the economy of Botswana, rising to this very dominant position in a relatively short time. Debswana was only incorporated in June 1969, to develop the Orapa diamond mine. This mine went into production in July 1971, followed 6 years later by Letlhakane. The Orapa mine's annual capacity is now 4,500,000 carats while Letlhakane's is 400,000 carats. At Orapa, the split by value is roughly 80 percent industrial and 20 percent gem, while at Letlhakane it is virtually the opposite of 80 percent gem and 20 percent industrial.

At Jwaneng, 25 to 35 percent of the annual 4,500,000 carats will be gems. This will give a capacity output of an estimated 1,600,000 carats of gem grade per year. The famous CDM (Pty) Ltd. operations in South West Africa (Namibia), which contain a very high proportion of gemstones, produced 1,247,960 carats in 1981. Thus Debswana will ride high among the gem producers.

Three Open Pit Mines

Orapa, Letlhakane, and Jwaneng are all open pit, shovel and truck operations. Each deposit is a kimberlite pipe. A great deal of exploration has been devoted to diamonds in Africa this century, but only seven major diamond-bearing pipes have been discovered—three of them are the Botswana pipes. The Orapa

SLUDGE PLANT with a simple ball mill was used for initial sampling of Jwaneng pipe.

pipe is the second largest in the world with a surface area of around 110 hectares (272 acres). It is second only to the Williamson mine at Mwadui in Tanzania, which covers 146 hectares (360 acres). Lethlakane is in fact mining two small pipes. Since it is only some 40 kilometers (25 miles) southeast of Orapa, Lethlakane comes under the same general manager, resident at Orapa. Orapa itself is about 380 kilometers (236 miles) almost directly north of Gaborone, the Botswana capital.

Debswana's importance to the country does not stop with the value of its products. It employs about 3,700 local citizens, a truly significant figure when one considers that the total population is only about 900,000. Then, of course, there are the ancillary industries and revenues generated by the establishment of a major mining industry.

Burgeoning Mineral Potential

From the mining point of view, perhaps the most important benefit has been the intense exploration carried out by De Beers and other mining companies, which has greatly increased the knowledge of Botswana's mineral potential. At the time of independence in 1966, it was generally thought that Botswana had little mineral potential. Three years later, in 1969, this misconception was well and truly shattered when it was confirmed that a large diamond pipe existed in the area of Orapa/Letlhakane.

In the same year the potential value of the Selebi-Phikwe nickel-copper deposits were established. While it is true that Selebi-Phikwe has encountered many problems since production started in early 1974, that does not detract from the importance of the ore bodies. Selebi's reserves were estimated at 31,000,000 tons containing 1.36 percent nickel and 1.12 percent copper, while Phikwe contained 12,600,000 tons at 0.74 percent nickel and 1.50 percent copper.

Diamonds and coal, although both carbon, do not always go together, but it is becoming apparent that they do in Botswana. Major reserves of coal are currently being investigated by such companies as Charbonnages de France and Shell Coal Botswana (Pty) Ltd., and there is talk of exports of up to 15,000,000 tons per year in the not too distant future.

Elsewhere, considerable copper deposits have been found in the Ghanzi district in the central western area of the country, near the South West African border. Other known prospects include silver, uranium, and more nickel. Although mining is currently concentrated in the east of the country, prospectors are already well established in the Kalahari with great promise for the future.

Unusual Kimberlite Find

The discovery of Jwaneng stands out as a major exploration achievement. The three-lobed pipe was discovered in 1973, buried beneath 30 to 50 meters (98 to 164 feet) of Kalahari sediments. To discover a pipe below such a depth of overburden was truly a major accomplishment. Exploration continued for four years at Jwaneng before the pipes were discovered. It is situated 125 kilometers (78 miles) west of Gaborone.

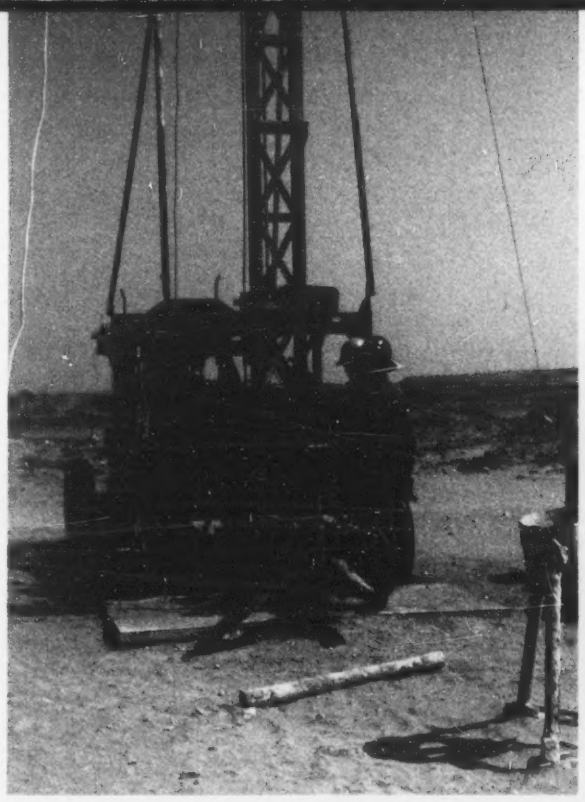
In 1969 geological teams started taking surface sand samples over a grid in the area. The samples were analyzed and found to contain garnets and ilmenites, minerals associated with kimberlites. This was followed by airborne geophysical surveys, which revealed anomalies indicating the targets for exploration drilling. Drilling proved the presence of kimberlite and over the next five years the limits and diamond contents of the pipes were determined. The outline drilling began in 1973, evaluation drilling in 1976.

The surface area of the pipes is about 54 hectares (133 acres). This area was divided into 50-meter (164-foot) blocks and a 380-millimeter (15-inch) hole was drilled in each block, to a depth of 200 meters (656 feet). The sludge from the holes was treated in a small plant to establish the diamond content in each 6 meters (20 feet) of the borehole. In addition, six shafts were sunk through the overburden into the pipes and the rock extracted in this manner was treated in the bulk sample plant. The shafts were 3 meters (9.8 feet) square, sunk to a depth of 165 meters (541 feet). Horizontal development from the bottom of the shafts provided further bulk samples. Drilling of the northeast lobe continued until late 1982, while the other two lobes, central

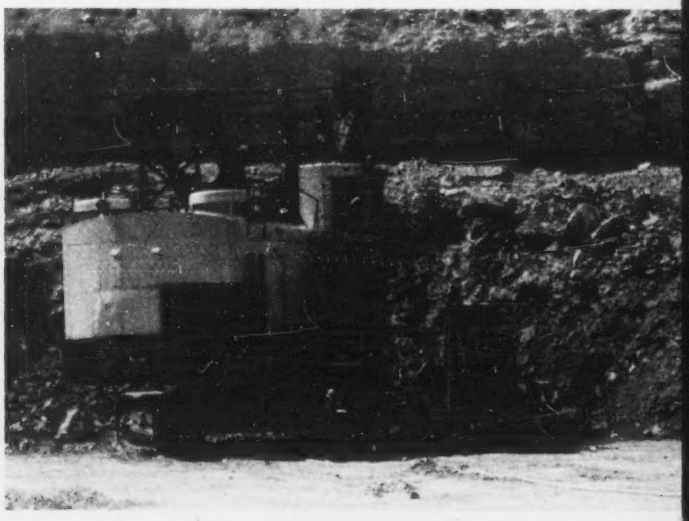
Table 1.
Botswana diamond mine production

	Metric tons mined		Carats per 100 tons		Total carats produced		
	1980	1981	1980	1981	1980	1981	1982*
Orapa	7,329,600	7,402,000	64.12	62.21	4,699,969	4,530,720	4,500,000
Letlhakane	2,112,900	2,229,000	19.00	19.27	401,423	429,532	400,000
Jwaneng	—	—	—	—	—	—	2,500,000

*provisional



LEFT, a churn drill at work. Drilling of the northeast lobe continued until late 1982, while the other two lobes, central and south, had already been fully drilled. **BELOW,** strict attention to good clean-up around the shovel and truck loading area at Jwaneng has increased tire life significantly, from about 4,000 to 6,000 hours. If dozers are unavailable for this maintenance operation, the shovel is stopped. **RIGHT,** drilling and loading in the open pit. Bowl scrapers strip the sand overburden, exposing faces high enough for electric shovels.



and south, had already been fully drilled.

The sludge sampling plant was a fairly simple unit that employed ball mills, with the undersize going to waste and the oversize reporting to grease tables for diamond separation. The 50-ton-per-hour bulk sample plant, which is still operating, is more sophisticated and includes heavy media separation (HMS). All the information from the boreholes, shafts, and sampling plants was used to determine an average grade for each 50-meter (164-foot) square, 12-meter (39-foot) deep block in the pipes.

Mining the Central Lobe

Production commenced in the central lobe with cut 1. Waste stripping for cut 2 is scheduled to commence in mid-1983. In the future, cut 3 will extend operations into the south lobe. Terex S24 bowl scrapers perform the initial stripping of sand overburden. The scrapers expose faces high enough to allow the 7.6-cubic-meter (9.9-cubic-yard) P&H 1900AL electric shovels to move in. The benches are 12 meters (39 feet) high and, at present, the sump lies on bench 7, 80 meters (262 feet) below surface.

Table 2.
Mining equipment at Jwaneng

Number of units	Make and model
3 electric shovels	P&H 1900AL
3 electric drills	Bucyrus Erie-45R
11 trucks	Caterpillar 777
1 rubber-tired loader	9-cubic-meter Caterpillar 992C
3 bowl scrapers	24-cubic-meter Terex S24
3 crawler dozers	Komatsu D355A
4 rubber-tired dozers	Caterpillar 824B/C
3 road graders	Wright 146

Blastholes, measuring 250 millimeters (9.8 inches) in diameter and 13.5 meters (44.3 feet) deep, are drilled on an 8-meter (26-foot) square grid by Bucyrus-Erie BE-45R units. Slurry explosive, supplied from an AECI plant on the mine site, is used with a 9-percent aluminum content in the toe of the holes when blasting calcrete/silvite and a 4 to 6-percent aluminum content when blasting kimberlite. Each hole is loaded with some 450 kilograms (992 pounds) of slurry at a temperature of about 100° C. Blasting normally takes place twice a week.

The ore is loaded into 77-ton Caterpillar 777 trucks and hauled to the primary crusher. Experience at Jwaneng has shown the importance of clean-up around the shovels in reducing tire costs. In fact, if no dozer is available, the shovel will be stopped until the loading area can be cleaned. Tire life on the trucks has been increased from about 4,000 to 6,000 hours in this way; very significant when one considers that each tire costs about $5,000.

The trucks dump directly into the primary crusher, an Allis Chalmers 54/74, where the ore is crushed to 150 millimeters (5.9 inches). The throughput of the crusher varies between 900 and 1,200 tons per hour, and averages 1,000 tons, depending on the material that is being crushed. The green kimberlite, deposits that are found near the surface, tends to be fairly sticky and passes through the crusher much slower than the red. A JCB 807B backhoe loader, fitted with a Montabert 5012 hydraulic breaker, is permanently on station at the crusher for secondary breaking of large boulders.

Ore from the crusher is transferred to one of three stockpiles. The high grade stockpile is for ore containing in excess of 50 carats per 100 tons. The medium grade contains 25 to 50 carats and the low grade has less than 25 carats. These stockpiles originally allowed the mine to get down to the high grade material quickly.

The ore from the stockpiles passes through a conventional, 900-ton-per-hour, diamond treatment plant where washing, screening and crushing to minus-25-millimeters (minus-1-inch) occurs—the fines of minus-1-millimeter (minus-0.03-inch) are sent to tailings. Heavy media separation uses a ferrosilicon medium with a specific gravity of 2.7. There are 19 Ore Sorter X-ray machines in the plant, for primary and secondary separation and reconcentration. Because of the poor foundation characteristics of the Kalahari sands, the whole plant has been built on piles sunk 20 to 30 meters (66 to 98 feet) down into the calcrete to provide a firm base.

The mine relies entirely on water from boreholes 50 kilometers (30 miles) to the north. Thus water conservation is of prime importance. Between 300 and 500 liters (9 and 132 gallons) of water are required to process each ton of ore,

BELOW, charging the 250-millimeter diameter, 13.5-meter deep blastholes with slurry explosive supplied from a plant on the mine site. The holes are drilled on an 8-meter square grid and loaded with some 450 kilograms of explosive at a temperature of about 100° C.

400,000 tons of water per month (25 days). Special facilities have been incorporated into the plant to recover water. In the jet sump the water/fines mixture is agitated by compressed air and pumped to the degritting plant where coarse particles are removed. The water is then fed to cyclones and on to thickeners where flocculent is added. Solids are sent to the slimes dam where water will be recovered in time and clear water is pumped back into the process. Despite the use of recovery procedures, some 10,000,000 liters (2,642,000 gallons) of make-up water is required each day.

Valuing, not a Simple Task

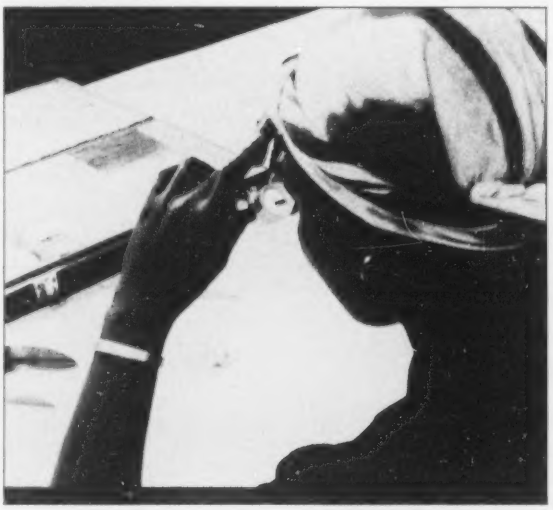
The diamonds from the X-ray machines finish up in the basement of the plant where they are hand-sorted for final recovery before being sent to the Botswana Diamond Valuing Company (BDVC) in Gaborone. The BDVC building is the tallest and most impressive in the city of Gaborone. It primarily consists of an 11-story tower block in which the diamonds from all three mines are sorted.

It has been sited to face due south and north after a computer sun angle analysis to determine the extent of the sun's

penetration into the building. Diamond evaluation is accomplished by visual assessment, so it is therefore essential to have natural light in the sorting areas without direct sunlight or glare. To achieve this, sorting takes place on the south side of the building in front of floor-to-ceiling laminated glass. These windows have been angled to make optimum use of natural light and to eliminate glare.

Diamonds from each of the three mines are received on the tenth floor of the BDVC where the first task is to agree the weight that the mine has sent. The parcels are then divided into 16 sizes by sieving on vibrating screens. They are then cleaned by boiling in nitric acid and sorted again on one of the many floors. Their size and the mine that they have come from determines where they are sorted. Each mine has its own team of sorters. In the case of Jwaneng, the team consists of 29 people. It is important for both the BDVC and the individual mines that each mine's output should be assessed separately.

EVALUATING DIAMONDS at the Botswana Diamond Valuing Company by visual assessment using indirect natural light.



The initial sorting process employs Gunsons Sortex X-ray machines for basic color grading and vibrating tables and roller sorters for shape splits. Final sorting is always done by human eye. Each individual diamond is sorted, checked, and re-checked for shape, clarity, and color. The sorting is compared against a standard parcel that is made up of a mixture from all three mines. The weights within each classification are then determined by automatic electronic scales and recorded on computer. Stock control is, naturally, of paramount importance throughout.

All Debswana's diamonds are sold to the Diamond Corporation of Botswana, part of the Central Selling Organization. The sales take place every five weeks, at which time about 500,000 carats are sold. ■

1955—The Botswana Diamond Story Begins

De Beers began searching for diamonds in the Tuli block of eastern Botswana in April 1955. The exploration program gradually extended south through the Gaborone and Lobatse blocks and then still farther south across the Kalahari to the Ghanzi district. All these operations were fruitless. In September 1961 extensive reconnaissance of the Kgatleng district, between the Tuli and Gaborone blocks, began.

An opportunity to explore the Bamangwato tribal territory, northwest of the Tuli block, came in 1962. The Selection Trust group was known to have found three diamonds along the banks of the dry Motloutse river at Foley and some distance upstream. Further prospecting along the course of the river had failed to indicate the source of the diamonds. When the search was abandoned, the exploration license passed in due course to a company in the De Beers Group.

The De Beers team first examined the river gravel sites of the previous expedition and confirmed the presence of diamonds at both. They likewise followed the Motloutse upstream, finding some small diamonds as far as 80 kilometers (50 miles) west of Foley, until the river and the trail disappeared. Other prospecting methods, not related to watercourses and streams, proved to be unrewarding.

The team rejoined the geologists who were following up the earlier reconnaissance of the Kgatleng district by an intensive exploration program. Operations had to be interrupted from time to time as other prospecting grants became available. By early 1966, it looked at last as if the years of hard work might not have been wasted. Two kimberlite pipes were located, the first ever found in Botswana. But after exhaustive testing they proved to be barren.

The geologists once again turned their thoughts to the Motloutse diamonds, almost obsessed with finding their source. Detailed prospecting of the river up to its headwaters, which had long been dry, was resumed but no kimberlitic minerals were found. However, curiously, traces of a large and shallow valley, cut evidently by an ancient river, were found beyond the headwaters of the Motloutse.

In trying to explain this anomaly, De Beers' chief geologist in Botswana, Dr. Gavin Lamont, recalled a theory of Dr. Alex du Toit, a former consulting geologist to De Beers. The theory held that, in the past, there had occurred an extensive upward warping of the earth's crust along a line extending from Zimbabwe well into Botswana. If that were so, the real source of the Motloutse could have been far to the west of the upwarp. The diamonds found to the east at Foley could have been washed down by the river long before the upwarp occurred and cut off its flow.

To test this theory, Dr. Lamont and his assistant carried out an extensive, detailed sampling of the area to the west. The results were disappointing, revealing an inconclusive scattering of kimberlitic minerals. Was the upwarp theory wrong? To test it once more De Beers decided on rapid reconnaissance of an area much farther west, between Letlhakane and Mopipi. This time the geologists found abundant evidence of ilmenites and garnets of kimberlitic quality. It was now July 1966. A more detailed program was then undertaken. Eight months later, the first pipe was discovered. BK 1 is about 200 kilometers (124 miles) from those three small diamonds that for so many years had been the only tangible clues. A month later AK 1 was found. It was to become Orapa mine, taking its name from a small cattle ranch nearby.

Drilling and Evaluation

Initial investigation of the group of pipes found in the Letlhakane area suggested that the testing program should concentrate on AK 1. It was easily the biggest. When its surface area had been defined by drilling, it covered 112 hectares (277 acres). The nature and inclination of the sidewalls were established by much deeper drilling. To determine the grade, pits were sunk initially to depths of 6 to 12 meters (19.7 to 39.4 feet) at regular intervals across the pipe. The material from the pits was treated in small rotary pans.

AK 1 proved to be a secondary kimberlite, which meant that its diamonds had been redistributed haphazardly as a result of some volcanic eruption, and that intensive and prolonged testing would be necessary to obtain a reliable indication of grade. More pits were sunk, to progressively greater depths and at closer intervals, until there were 200 pits and shafts from which the pipe could be sampled down to depths of 37 meters (121.4 feet).

By the end of 1968 results were sufficiently complete to show that the grade remained good below the superficially enriched zone. The huge pipe was certainly payable, and De Beers took the decision in principle to develop a mine. Sampling of the pipe continued so that the engineers would have the fullest possible geological information on which to base the mining plan.

The diamondiferous ground was now being treated in three plants with a combined capacity of 300 tons per day. Eventually those plants, working three shifts, were treating up to 900 tons per day—an unusually large tonnage for what was still a prospect, rather than a mine. The concentrated gravels were passed over vibrating grease tables for final diamond recovery.

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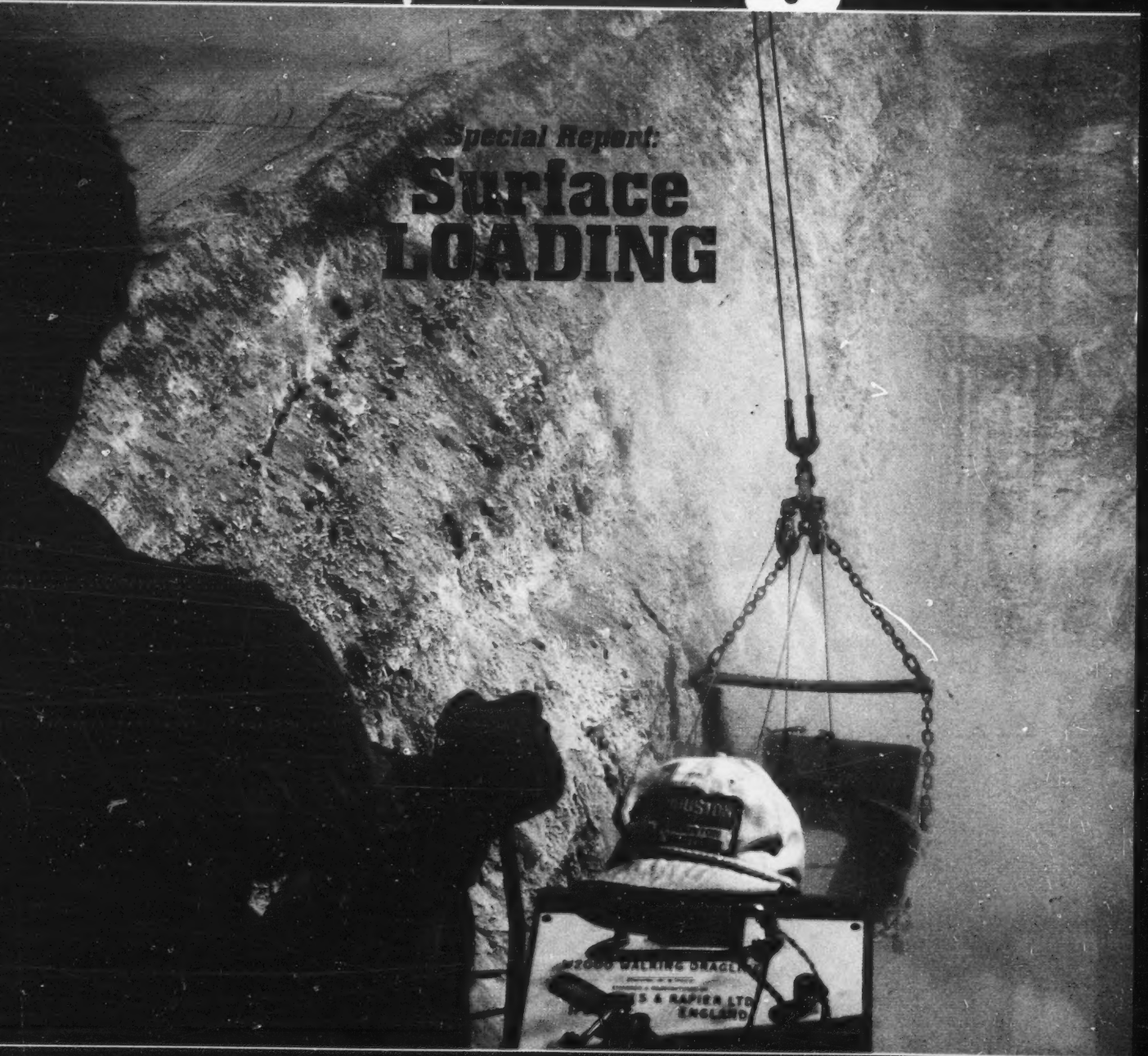

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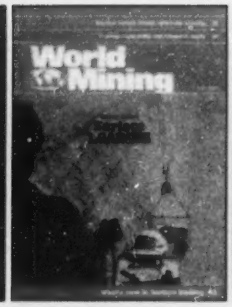

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THE COVER

The view from inside a Ransomes & Rapier dragline. This month, WORLD MINING examines surface loading economics, reviewing the equipment, its maintenance, and its energy requirements. *Photo by John R. Chadwick.*

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Lesser mobility can be overcome and the savings in energy and maintenance costs can be dramatic

Electric versus Diesel hydraulic shovels

By **Phillippe Fritz**
Chief Engineer
Heavy Machinery Product Planning
Poclain, France

A survey carried out in France showed that, in 1980, quarries mining limestone, igneous rocks, sand, and gravel consumed energy amounting to 354,500 mcTOE.[1] Most electricity is used by the processing plant for such operations as screening, crushing, washing, and dedusting.

Fuel oil is used in the mobile loading and hauling fleet. Energy costs, marginal only ten years ago, have become a key budget item for these machines. In that period, fuel oil costs have increased by a factor of more than 9. Fuel oil accounts, on average, for some 35 percent of the total running costs of a modern hydraulic shovel, with a consumption of between 0.08 and 0.12 liter (0.02 and 0.03 gallon) per ton loaded. Already we can see a major improvement on the figures of ten years ago, 0.15 to 0.19 liter (0.03 to 0.05 gallon) per ton.

However, further energy cost reductions can be achieved through the use of electrically powered hydraulic shovels. Some examples of this are shown in Table 1. Yearly consumption figures were calculated on the basis of 1,800 hours of operation per year. Cost figures are based on prices prevailing in France in late September 1982: fuel oil at 2.40 Francs per liter and electricity at 0.45 Franc per kilowatt-hour. Conversion to United States dollars was made at a rate of 7.2 Francs per dollar.

The conjunction of electric motor and hydraulic system gives a power factor superior to 0.8. So there is no need for special corrective capacity upstream from the excavator, and no risk of higher energy bills for the user.

Electro-hydraulic machines can be used in conditions similar to those for Diesel machines. The cost savings speak for themselves. Furthermore, sizeable economies can be achieved by correctly appraising on-site power requirements from the electricity utility, restricting shovel use during peak hours, and fully utilizing the machine during off-peak hours. Such careful planning could further increase the annual saving at Mine 1 to 60,000 Francs ($8,333).

There are, however, other considerations. An electro-hydraulic shovel costs more to purchase. The price difference varies with machine size, but in any case the extra capital can be paid off within 2,000 operating hours. There is less maintenance with an electric shovel since there are no re-fueling stops, oil changes, or oil filter changes. As a general rule, daily servicing time is halved. A final consideration relates to the capital cost of electrical facilities on-site, transformer and power line. This will depend on existing installations and the utility involved.

Some users are put off by the trailing electrical cable of electric units. Except where considerable traveling is required, for limited and varying tasks of short or medium duration, the lesser mobility of

ELECTRIC 1000CK working in temperatures to minus-50° C in the Ural-Mash asbestos mine in the Soviet Union. Electricité de France calculates that a 1000CK working 220 days per year, 8 hours per day, would produce 3,520,000 metric tons, at 63 percent utilization.

electro-hydraulic shovels should not be a problem. Such machines can work perfectly well along faces between 400 and 500 meters (1,312 and 1,640 feet) in length, fed by a 300-meter (984-foot) power cable. Mobility can be further increased by disconnecting the hydrostatic transmission so that the shovel can be towed over long distances, or by connecting the shovel's transmission to a Diesel-hydraulic module.

Certainly, care must be taken to avoid damage to the power cable. Here the user can provide tailored solutions, such as the slewing cable-support arm or automatic take-up drum.

Capacity of site installations to power such machines should be specifically analyzed by mine management in conjunction with the electricity utility and shovel manufacturer. Table 2 gives an indication of the power supply and transformer capacity required, depending on the size and power rating of shovel selected.

Further advantages of electric units include low noise pollution, no pollution through exhaust fumes, and increased reliability. Electro-hydraulic units can operate in temperatures ranging from minus-40° C to plus-50° C. ■

Reference
1. mcTOE = metric tons oil equivalent.
1 TOE = 4,000 kilowatt hours or 1,189 liters (312 gallons) of fuel oil

Table 1. Diesel-hydraulic vs. electro-hydraulic excavator costs

42-ton Diesel-hydraulic shovel	42-ton electro-hydraulic shovel
Mine 1	
Hourly loading rate: 300 to 350 tons	
166-kilowatt Diesel engine	160-kilowatt electric motor
Average fuel consumption:	Average electricity consumption:
27 liters per hour	106 kilowatt-hours
48,600 liters per year	194,400 kilowatt-hours per year
Average energy costs:	Average energy costs:
48,600 x 2.40	194,400 x 0.45
= 116,640 Francs per year ($16,200)	= 87,480 Francs per year ($12,150)
Annual cost saving: 29,160 Francs ($4,050)	
65-ton Diesel-hydraulic shovel	**65-ton electro-hydraulic shovel**
Mine 2	
Hourly loading rate: 500 to 550 tons	
240-kilowatt Diesel engine	220-kilowatt electric motor
Average fuel consumption:	Average electricity consumption:
41 liters per hour	165 kilowatt-hours
73,800 liters per year	297,000 kilowatt-hours per year
Average energy costs:	Average energy costs:
73,800 x 2.40	297,000 x 0.45
= 177,120 Francs per year ($24,600)	= 133,650 Francs per year ($18,563)
Annual cost saving: 43,470 Francs ($6,037)	
120-ton Diesel-hydraulic shovel	**120-ton electro-hydraulic shovel**
Mine 3	
Hourly loading rate: 700 to 750 tons	
Two 220-kilowatt Diesel engines	Two 220-kilowatt electric motors
Average fuel consumption:	Average electricity consumption:
70 liters per hour	285 kilowatt-hours
126,000 liters per year	513,000 kilowatt-hours per year
Average energy costs:	Average energy costs:
126,000 x 2.40	513,000 x 0.45
= 302,400 Francs per year ($42,000)	= 230,850 Francs per year ($32,063)
Annual cost saving: 71,550 Francs ($9,937)	

Table 2. Power supply and transformer rating dependent on shovel size

Shovel weight (metric tons)	Shovel rated power (kilowatts)	Power supply (kilowatts)	Transformer rating (kilovolt-amps)
42	160	150	250
65	220	280	315
120	440	400	630
190	600	500	800

ELECTRIC 600CK working in Neyveli lignite mine, India. With 2,280 hours, this machine averaged 95 percent availability. The superintendent comments, "We operate three 600CK's, two Diesel and one electric, but as a matter of fact, we should have three electric."

Comparing net electricity and Diesel consumption for systems operating draglines, shovels and trucks, and scrapers

Energy consumption in open pit mining

By **Dan Nilsson**
and **Nagendra P. Reddy**
Department of Mining Engineering
Michigan Technological University

Although energy costs are not everything, they have become a critical factor in the profitability of many mining ventures. An important research project underway in the United States is investigating the energy consumption pattern in different mining operations.

This examination of energy consumption in a hypothetical open pit coal mine considers the use of various types of mining equipment. In 1977, the United States Bureau of Mines published a report (Information Circular 8761) in which the cost of mining an area by dragline, shovel, and scraper methods for stripping was evaluated. Energy consumption was not explicitly studied in that report. Here, the same theoretical deposit has been considered. Energy consumption has been calculated using equipment requirements as a base.

The deposit is assumed to contain a single coal seam 15 meters (50 feet) thick, overlain by 20 meters (70 feet) of sandstone, soft shale, and soil. Coal production is 5,000,000 short tons per year, with a mine life of 20 years.

This article evaluates energy consumption in overburden stripping using draglines, shovels and trucks, and scrapers. It must be stressed that each coal deposit is unique. The figures arrived at cannot be used directly to calculate energy consumption for any other mine. In a real mining situation, actual conditions must be used. Therefore, conclusions drawn cannot be applied generally.

Dragline Mine

This method uses a 23-cubic-meter (30-cubic-yard) dragline for stripping overburden and two 7.6-cubic meter (10-cubic-yard) coal loading shovels with eight 85-ton coal haulers for mining coal in a pit 33.5 meters (110 feet) wide. Two 85-ton trucks are included as spares.

Overburden preparation is assumed to require drilling 270-millimeter (10.6-inch) diameter vertical blastholes on a 7.6- by 7.6-meter grid pattern. Blasting is accomplished with Anfo. A 25-grain detonating cord is used for the trunk line, 50-grain cord for down lines, and one primer per hole for ignition. Progressive timing and buffer shooting are practiced. A 224-kilowatt (300-horsepower) dozer levels the bench before drilling commences. An electric rotary blasthole drill with a pulldown of 547 kilonewtons (125,000 pounds) is used.

Shake-up blasting is needed as the seam is thick. This involves drilling 200-millimeter (7.9-inch) holes on the same grid pattern as in the overburden. Anfo is again used with progressive timing and similar priming and detonating practices as those in the overburden.

Reclamation consists of regrading spoil piles and deposition of subsoil and topsoil. Earthmoving and deposition will be handled by a 16.8-cubic-meter (22-cubic-yard) elevating scraper, while leveling is accomplished by a 224-kilowatt (300-horsepower) dozer. Revegetation is contracted in all of the systems.

At the shovel and truck operation, two 16.8-cubic-meter (22-cubic-yard) shovels and eight 120-ton rear dump trucks are used for overburden removal. In the coal, two 7.6-cubic-meter (10-cubic-yard) shovels and eight 85-ton coal haulers are employed. Two each of the 120- and 85-ton trucks are included as spares.

The initial mining cut is 36.6 meters (120 feet) deep. Production starts when proper depth is attained for each bench. Overburden and topsoil are stockpiled on the crest and sides of the cut until berm, slopes, and floor width are in proper relation to the back filling. Minimum berm width is assumed to be 61 meters (200 feet). Overburden, coal drilling, and blasting are the same as in the dragline system. Reclamation involves regrading overburden that is dumped by trucks.

With the scraper system, tandem-powered, push-pull scrapers are used since they possess the traction to self-load in unconsolidated and harder material. This type of scraper was deemed to be the most practical and economical for handling overburden. Other scrapers can assist in loading.

The mine here is a moving panel employing progressive backfill. Topsoil is removed in advance of the panel and deposited on the backfill area by 16.8-cubic-meter (22-cubic-yard) elevating scrapers. Overburden is pre-blasted and

Table 1. Machinery requirements

	Dragline	Shovel/truck	Scraper
Dragline, 23-cubic meter	1		
Shovels, 16.8-cubic meter		2	
Scrapers, 16.8-cubic meter			16
Coal shovels, 7.6-cubic meter	2	2	2
Overburden trucks, 120-ton		10	
Coal haulers, 85-ton	10	10	10
Dozers	2	1	4

In addition, each system would require one overburden drill, scraper, rubber-tired loader, grader, fork lift, crane, 23 service vehicles, and four pumps.

Table 2. Hourly fuel consumption

	Working conditions					
	Favorable		Average		Unfavorable	
Vehicle	Factor percent	Gallons[1]	Factor percent	Gallons[1]	Factor percent	Gallons[1]
Crawler	60	0.034	70	0.040	80	0.046
Scraper (self-loaded)	48	0.027	55	0.031	65	0.037
Scraper (push-loaded)	40	0.023	50	0.029	60	0.034
Front-end loaders	35	0.020	45	0.026	55	0.031
Bottom dumps	30	0.017	40	0.023	50	0.029
Haulers	25	0.014	35	0.020	45	0.026

Source: "Production and Cost Estimating of Material Movement with Earth Moving Equipment," Terex 1981.
This table has been used to calculate fuel consumption for equipment lower than 700 horsepower.
[1]per horsepower-hour

then removed by 13 tandem-powered, push-pull scrapers. Three of these scrapers are included as spares. Overburden, coal preparation, and reclamation are the same as in the previous systems. The panel is 122 meters (400 feet) wide and 610 meters (2,000 feet) long.

As previously mentioned, the mine life is assumed to be 20 years, with a recovery of 90 percent. Thus raw coal production is 5,000,000 tons per year, while overburden stripping is 91,350,000 tons per year.

A dragline system, because of high capital investment, is assumed to work 360 days per year with three eight-hour shifts per day. Shovels, trucks, and scrapers work only 250 days per year with two eight-hour shifts per day. Shovels and haulers are used for all coal mining, operating 250 days per year on two eight-hour shifts per day.

Although energy costs are not everything, they have become a critical factor in the profitability of mining ventures

Energy Consumption

Engine fuel consumption rate depends on engine horsepower and vehicle duty cycle. The consumption rate for a particular type of vehicle may be calculated by multiplying the engine gross horsepower by the consumption rate (gallons per horsepower-hour) shown in the formula below. Factors in the formula are based on a nominal fuel consumption rate of 0.4 pound per gross horsepower hour. Since there are 7.01 pounds of fuel in a gallon:

Fuel consumption =
0.057 gallon per horsepower-hour x
percent duty cycle

This formula is valid for Diesel engines up to 700 horsepower. The duty cycle is the representative percent of the time the engine is operating at maximum output. Diesel engines rated higher than 700 horsepower and gas turbine engines may have a higher fuel consumption rate. New factors should be established for them.

For instance, in order to find the fuel consumption of a 500-horsepower, push loaded S-24B scraper under average working conditions, use the following formula:

Fuel consumption =
0.029 gallon x
500 horsepower =
14.5 gallons per hour

Hourly fuel cost will then equal hourly fuel consumption (taken from Table 2) multiplied by cost per gallon.

Energy consumption for the larger equipment, like draglines and shovels, trucks and scrapers, is calculated on the basis of information from manufacturers. Tables 3 and 4 summarize calculation of the consumption of Diesel fuels and electric power. Total energy requirements for this equipment are compared in Table 5.

Energy Use Measure

Two measurements of energy use are normally employed. The first, termed useful energy, or net energy, represents the direct theoretical heat value of fuels and purchased electricity used. Gross en-

Table 3. Consumption of diesel fuel

	Unit horsepower	Gallons per hour and unit	Hours per year	Gallons per year
Dragline system:				
8 coal haulers (plus 2 spares)	670	20	3,320	531,000
2 dozers	300	11	3,320	73,000
1 scraper	330	11	3,320	36,000
1 front-end loader	130	5	3,320	16,000
1 grader	180	6	3,320	20,000
25 other vehicles	150	4	1,000	100,000
Total				**776,000**
Shovels and trucks:				
8 overburden trucks (plus 2 spares)	1,200	25	3,320	664,000
1 dozer	200	8	3,320	26,000
As above for dragline system				776,000
Total				**1,466,000**
Scrapers:				
13 scrapers (plus 2 spares)	450	25	3,320	1,079,000
2 dozers	300	11	3,320	73,000
As above for dragline system				776,000
Total				**1,928,000**

In addition, some oil may be used for other purposes, such as spraying the coal to be shipped. This is not included.

Table 4. Electrical consumption

	Average kilowatt-hours per unit hour	Hours per year average load	Kilowatt-hours per year
Scrapers:			
2 coal shovels	475	3,320	3,200,000
1 coal drill	275	3,320	900,000
1 overburden drill	450	3,320	1,500,000
Pumps, etc.			800,000
Workshops, offices, etc.			1,600,000
Other equipment			1,600,000
Total			**9,600,000**
Shovels and trucks:			
2 stripping shovels	1,000	3,320	6,600,000
Everything else as above			9,600,000
Total			**16,200,000**
Draglines:			
1 dragline	1,800	7,170	12,900,000
Everything else as above			9,600,000
Total			**22,500,000**

Table 5. Total energy requirements

	Dragline	Shovels and trucks	Scrapers
Electric energy:			
Kilowatt-hours/year[1]	22,500	16,500	9,650
Kilowatt-hours/short ton of coal	4.5	3.3	1.9
Diesel fuel:			
Gallons per year[1]	776	1,466	1,928
Gallons per short ton of coal	0.15	0.29	0.38

This table does not show which alternative is preferable from the point of view of energy consumption. To show that, the amounts of diesel fuel and electricity must be converted to the same unit, that is British Thermal Units (Btu).
[1] x 1,000

Table 6. Total energy requirements and energy use measures[1]

	Dragline	Shovels and trucks	Scrapers
Gross energy:			
Electricity	238	173	101
Diesel fuel	111	210	276
Total	347	383	377
Net energy:			
Electricity	77	56	33
Diesel fuel	111	210	276
Total	188	266	309

[1]Btu/year x 1,000,000,000

Net energy consumption for various mining systems

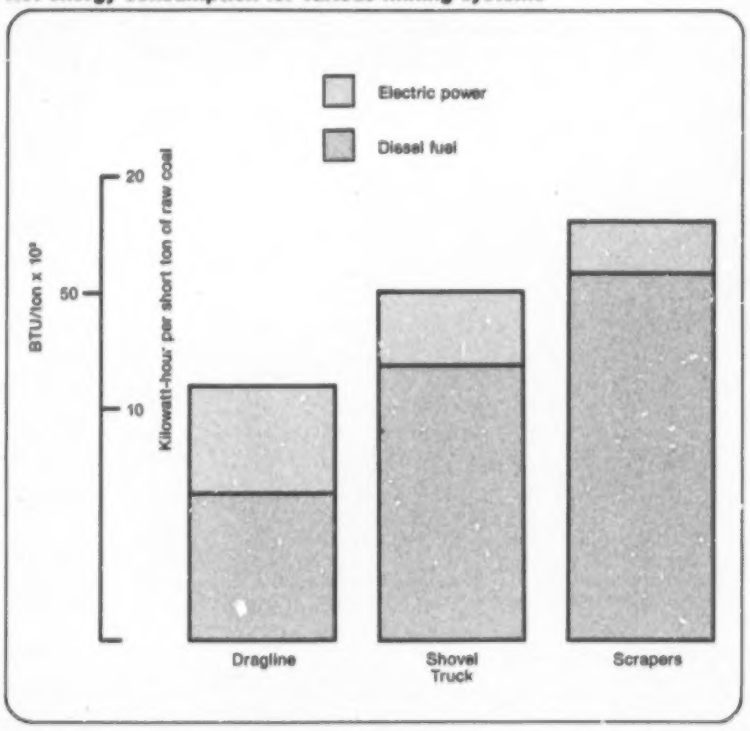

Table 7. Total net energy requirements

	Dragline	Shovels and trucks	Scrapers
Btu/year[1]	188,000,000	266,000,000	309,000,000
Btu/short ton[1]	37.6	53.2	61.8
Kilowatt-hour equivalents per ton	11.0	15.6	18.1
of which:			
Electricity, percent	41	21	11
Diesel fuel, percent	59	79	89

[1]x 1,000

Table 8. Annual energy costs

Dragline:		
Electric power	22,500 kilowatt-hours x $0.05	1,130,000
Diesel fuel	776,000 gallons x $1.25	970,000
Total dollars per year		2,100,000
Dollars per ton of raw coal		0.43
Shovels and trucks:		
Electric power	16,500,000 kilowatt-hours x $0.05	830,000
Diesel fuel	1,466,000 gallons x $1.25	1,830,000
Total dollars per year		2,660,000
Dollars per ton of raw coal		0.53
Scrapers:		
Electric power	9,550,000 kilowatt-hours x $0.05	480,000
Diesel fuel	1,928,000 gallons x $1.25	2,400,000
Total dollars per year		2,880,000
Dollars per ton of raw coal		0.58

ergy differs only in that it includes heat losses incurred by electric utilities in the process of generating power. The gross measure takes into account both direct and indirect calls upon energy resources by mining, at least insofar as electricity is concerned.

In a study of gross energy consumption, a conversion factor of 10,470 Btu per kilowatt-hour should be used, while a study of consumption of useful energy should use 3,412 Btu per kilowatt-hour.

Table 6 summarizes total energy consumption in the hypothetical mine, for two alternative energy measures. For Diesel fuel, a value of 143,000 Btu per gallon has been used.

Following the gross energy approach, it is difficult to draw any conclusion; the dragline seems to be the best alternative, although differences are minimal. With the net energy approach, the dragline should certainly be chosen.

The gross energy measure is helpful in indicating the impact of an industry on total energy use

A more complete measure of gross energy demanded would take into account other conversion and transmission losses. One of these is the transmission loss in natural gas.

While the gross energy measure is helpful in indicating the impact of an industry on total energy use, it is not a good indicator of effects on energy use brought about by changes within the industry. Net energy more accurately reflects technological developments, as well as changes in production processes and product mix, on energy use over time.

A decrease in fuel consumption in the minerals industry, with a corresponding increase in electricity purchases, should result in a lower Btu figure to the extent that conversion losses are shifted to a public utility.

A gross energy measure should give a more pessimistic picture for using electric equipment like draglines than with a net energy approach. This is especially gloomy if one considers that, in the Unit-

ed States, electricity is produced from domestic coal and Diesel fuel, to a large extent, from imported oil.

No decision is based solely on energy consumption. Albeit energy conservation is important, overall economy is the main objective in any mining venture. Energy losses in supplying power to the industry, be it gas, electricity, or refined petroleum products, are taken into account in prices the consumer has to pay for different types of energy. This further strengthens the conclusion that net energy must be used.

Energy consumption using a net energy approach is shown in Table 7. The table shows how large a part of the total consumption is electricity and how much is Diesel fuel. For the dragline system, electric power accounts for about 40 percent of the total, with scrapers only 11 percent.

Net energy more accurately reflects technological developments and changes in production processes and product mix

Energy Costs

In conclusion, it is obviously of interest to compute energy costs for the various mining systems, as shown in Table 8, using $0.05 per kilowatt-hour for electric power and $1.25 per gallon for Diesel fuel. This table demonstrates that the dragline gives the lowest cost, at $0.43 per ton.

As has already been mentioned here, energy costs are not the only thing to be considered. The dragline option looks best in this analysis, based on energy costs. However no account has been taken of such factors as capital costs, wages, etc. There are many other considerations that come into play when designing the most economic mining system for a given deposit.

The Office of Surface Mining, United States Department of the Interior, is sponsoring a research project at Michigan Technological University, entitled "The Effect of Increasing Energy Costs on the Future Relation Between Open Pit and Underground Mining." The research project seeks to learn about energy consumption patterns in different types of mining operations. This article was drawn from the findings of that project.

While the material here is based upon work supported by the Office of Surface Mining, under Grant No. G5105032, any opinions, findings, and conclusions or recommendations expressed are those of the authors, Nilsson and Reddy, and do not necessarily reflect the views of the Office of Surface Mining. ■

THE SYSTEMS

Dragline

A dragline performs two functions: excavating and conveying. It has a five element cycle: drag, transport, dump, return, and position. Usual cycle time is about 55 to 60 seconds, depending on size and conditions.

Draglines in western United States stripping operations usually handle blasted sedimentary rocks to depths of over 30 meters (100 feet). Draglines can move material at lower cost than other methods, except for bucket-wheel excavators. Walking draglines range from 11.5 to 168 cubic meters (15 to 220 cubic yards) in capacity. They are limited to travel on gradients less than 8 to 10 percent, and average around 0.16 kilometer (0.1 mile) per hour.

Size depends on amount of overburden, required production, and total coal reserves of the property. Dragline digging action is related to bucket weight during the drag cycle. A dragline can handle several rock types and sizes.

When formulating a preliminary design for a dragline mine, five factors must be determined from handbooks or site investigations: angle of highwall, angle of repose, cut width, swell, and bench height. Pit design also depends upon required production, geological factors, working area, and equipment limitations. The pit should be of adequate size to attain required production, accounting for geological features that affect slope stability, depth and thickness of coal, etc. Areas must be sized for clearances, safety, and machine maneuverability while also maintaining working capabilities of the equipment.

The main production factors that affect dragline performance are deadheading, chopping, rehandling, and keycutting. Deadheading is walking the dragline without excavating. Rehandling of material is dependent on boom length, pit width and depth, and mining method. Chopping is usually performed on interburden by moving the unit to an interburden or spoil area. The dragline (on the spoil area) faces the highwall and chops interburden. The swing angle is increased and the dragline must work at a lower elevation, increasing hoist and spoiling height. A dragline and its bucket are not designed for chopping, so efficiency is drastically lowered. Keycutting is the excavation of a trench in the highwall to obtain a competent area for positioning the machine.

Pit width can be highly variable and is dependent on safety, slope stability, and overburden depth. The narrowest practical pit is usually the most economical. It decreases rehandling requirements at curves, entries, and high cover areas. Dragline cycle times are also reduced, and reclamation starts more rapidly. Spoil piles are more closely spaced, so regrading costs are less.

Shovels and trucks

Such mining is characterized by excellent production variability compared with the other two systems. This method of stripping offers great versatility in material handling, but maximum production can only be achieved by rigidly planned, coordinated, and scheduled operating procedures. Principal advantages of shovel and truck stripping are natural stratification in backfilling and excellent production flexibility.

When considering shovels and trucks as a method of coal extraction, required production is the prime design parameter. Equipment must fulfill current production requirements and have enough flexibility to be integrated into future changes in the mining plan.

Compatible haulage unit tonnage capacities are usually three to five times the shovel dipper volume, and bench heights are limited to 1.5 meters (5 feet) lower than the cutting height of the shovel. Berm width, working slopes, etc., are a function of equipment, but major consideration must be given to geology.

Scrapers

These machines offer a high degree of versatility and mobility. Economics and practical ranges of such units rely on short hauls and easily loaded and spread material. Successful application of scraper or scraper-dozer mining lies in proper coordination of machines and production cycles. Scrapers are normally used where material volumes are low or in addition to other stripping equipment.

Most scraper applications are in such materials as friable shales or coal, and for one-way hauls of 300 to 1,500 meters (1,000 to 5,000 feet). Some modern scrapers can handle ripped or blasted rocks with an edge size up to 0.6 meter (2 feet), but tire wear, maintenance costs, and downtime are increased. Loading such material can cause extreme damage to tires and undercarriage.

Scrapers offer a low cost per ton on short to medium hauls while providing maximum flexibility in stripping and reclamation plans. When scrapers are employed, differences in digging characteristics and economic transport distances must be considered and compared with other loading and hauling methods.

There are three major types of wheeled scraper: standard, tandem-powered, and either single- or twin-engine elevating scrapers. Standard units are Diesel powered with front-wheel drive. Their capacity ranges from 15 to 42 cubic meters (20 to 54 cubic yards) at powers up to 410 kilowatts (550 horsepower). The four-wheel drive of tandem scrapers gives greater loading power and gradability. Their maximum capacity is 42 cubic meters (54 cubic yards) and power up to 708 kilowatts (950 horsepower). The elevating conveyor of the elevating scraper eases loading. Such units are effective for independent loading and very short hauls. Other types may or may not require a pusher unit. Only elevating or push-pull scrapers (scrapers hooked together while both are loading) can achieve full load without a push. The type of scraper or combination scraper/pusher chosen depends on the particular situation and geological conditions of the area.

Yearbook

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World Mining

AUGUST 1983

Yearbook

Production Equipment Catalog

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CATALOG, SURVEY, AND DIRECTORY

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The mining recession spread throughout the world. Molybdenum and nickel were particularly hard hit. The outlook remains good, however, for many commodities

Exploration and Development in 1982

By K. A. Grace
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GRACE

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World mine activity in 1982 decreased significantly from that of 1981. The effects on mining of the recessionary business cycle, which was felt strongly in the northern hemisphere in the latter half of 1981, spread worldwide in 1982. Mine closures, production cutbacks, and project deferrals became common, and the year closed with annual reports awash in a sea of red ink.

Nowhere was the effect of the industry's condition more noticeable than in North America. The value of United States non-fuel mineral production declined 21 percent to its lowest level since 1938, while Canadian base metal output was off 18 percent. Most production costs exceeded income due to depressed commodity prices and under-utilization of production capacity. In the United States, the price of lead fell from 31 to 20 cents a pound between January and December; zinc from 42 to 38 cents; molybdenum oxide (Climax) from $8.75 to $5.85 (with some producers and traders selling at $2.50). United States refined copper, at about 75 to 78 cents (with a low of near 60 cents), and nickel, at $3.20, stayed relatively even.

Tin remained fairly stable at just under $6.00 per pound most of the year, due to the International Tin Council's buffer stock purchases and production quotas.

For the producers of gold and silver, volatility was somewhat offset by the overall increase in price over the year. Gold, opening the year at $300 an ounce on a downward trend carried over from 1981, dropped to a low of $297 by midyear, but then rebounded to $448 by year's end. Silver's price trend closely paralleled that of gold, starting at about $8 an ounce and dropping to below $5 by midyear before starting a steady rise to over $11 by year's end.

For platinum group metals, the free market price of platinum dropped well below the producer quoted price of $475 per ounce, reaching a four-year low of about $250 per ounce in midyear.

Palladium decreased to about $50 per ounce (compared with the producer's cost of $110 per ounce) at the same time. Both these metals recovered towards year-end (and into 1983) but rhodium and iridium prices continued to slide.

With worldwide crude steel production down some 9 percent from 1981 (down 12 percent for the west, including a 40 percent slide for the United States), many iron ore mines ceased to produce and others cut production sharply.

The world surplus in oil, resulting eventually in price cuts by OPEC and non-OPEC producers, had an adverse effect on the search and development for alternative energy sources such as uranium, oil shale, tar sands, and geothermal.

An important negative factor in 1982 was the financial difficulty that plagued many countries, particularly in the developing world. Major devaluation of the Mexican peso is a prime example, but many other mineral-rich countries, including Peru, Brazil, and Venezuela, found themselves under tough International Money Fund-imposed spending and borrowing controls that severely restricted mineral development plans.

Although global in character, reduced mineral output and its effects on exploration and development were not evenly distributed geographically or by commodity. While production of copper, nickel, iron ore, molybdenum, uranium, tin, and fertilizer minerals was down, worldwide production of lead, zinc, and silver increased. Although United States uranium production decreased drastically, the Australian output increased significantly.

The overall effect of the minerals industry's poor condition on exploration and development was marked. Objectives were re-assessed, budgets trimmed, and professional staff idled. Only well-advanced (and successful) projects were continued, and then usually at a reduced pace. The major focus, if such a term could be used, of exploration and development in 1982 was on gold. As before, the main areas of activity were the United States, Canada, Australia, and South Africa, but precious metal discoveries were reported from locations worldwide. For silver, the main activity was, as before, in the United States and Latin America.

Exploration activity and expenditures, actual or planned, reflected these conditions, including both geographic and commodity preferences. Overall, exploration expenditures for the non-communist world in 1982 have been estimated at 10 to 15 percent less than in 1981 and on the decline. Thus, the Australian exploration expenditures, reaching a record $A463,000,000 ($408,000,000) for the year ending June 1982, is forecast to decline 13.7 percent for the period 1982-83.

Most United States and Canadian mining corporations cut back severely from 1981-82 exploration spending, and will continue this trend in 1983. The corporate exploration expenditures in Alaska, for example, were $36,000,000 in 1982 versus $76,000,000 in 1981, and are not expected to increase in 1983. The table on the next page shows worldwide expenditures made by several major mining companies on minerals exploration for the year to June 30, 1982.

Exploration Technology

New exploration techniques in 1982 centered around satellite and airborne sensing methods. An event of major interest to minerals exploration worldwide was the launching by the United States of the Landsat-4 satellite on July 16, 1982. In a lower orbit than its predecessors, this satellite has a seven-band thematic mapper as well as a four-band multi-spectral scanner. It has better discrimination of lithological units and the capability to produce natural color composite images. Early transmitter problems, however, may reduce the satellite's usefulness. (For a feature report on the thematic mapper, see WORLD MINING, March 1983, page 44.)

Another development in the field of space observation was the inclusion of a multi-spectral infrared radiometer and an imaging radar in the United States' Columbia space shuttle missions. The imaging radar, known as SIR-A, was able to penetrate 5 meters (16.5 feet) of dry sand overburden to "see" the underlying rock formations. NASA plans to use the shuttle in 1983 to launch relay satellites for transmitting data from Landsat-4 to Earth.

Testing continued in 1982 of the Daedalus airborne thematic mapper and the company's new Thermal Infrared Multispectral Scanner.

1982 expenditures on exploration

Company	Expenditure (multiply by 1,000,000)
Anaconda Co.	$94.9
Asarco Inc.	$18.5
Amax Inc.	$16.0
Exxon Corp.	$24.0
Newmont Mining Corp.	$16.7
Phelps Dodge Corp.	$12.6
St. Joe Minerals Corp.	$32.0[1]
Freeport Minerals Co.	$17.7
Homestake Mining Co.	$16.5
Noranda Mines Ltd.	$C39.7 ($31.8)
Rio Algom Ltd.	$C9.9 ($7.9)
Saskatchewan Mining Development Corp.	$C22.0 ($18.0)
Cominco Ltd.	$C53.0 ($42.0)
Consolidated Gold Fields Ltd.	£25.0 ($36.0)
MIM Holdings Ltd.	$A19.0 ($17.0)[2]
Gold Fields of South Africa	R14.7 ($13.4)[2]

[1]A new record
[2]Year to June 30, 1982

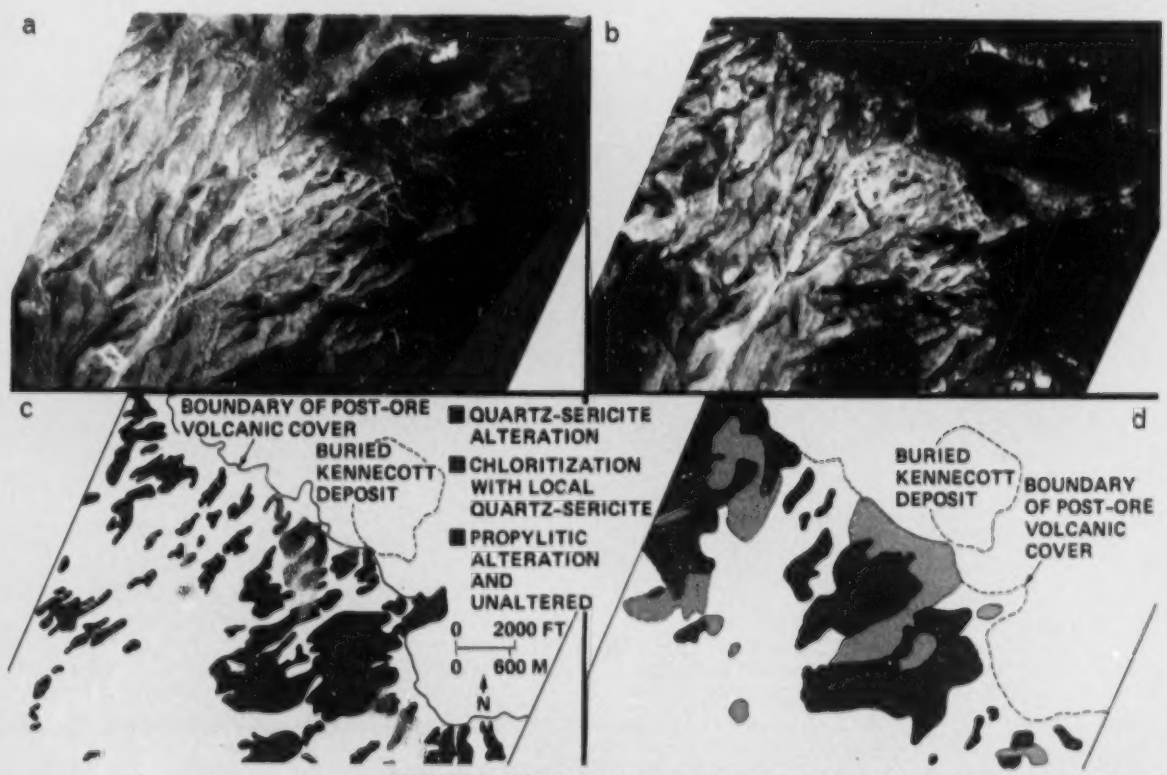
In the area of geophysical surveying, aeromagnetic gradiometer technology progressed with field testing in Canada. The method, originally developed by the Geological Survey of Canada, is said to eliminate problems that are due to diurnal changes. Companies carrying out field tests include Questor Surveys, EG & G Geometrics, and Kenting Earth Sciences, all of Ontario, Canada.

Ground geophysical measuring devices continued to be improved in capability while being reduced in size due to the use of micro-processor technology. New lightweight magnetometers were announced by several manufacturers. Both Gem Systems and Numec Ltd. of Toronto, Canada, produced a portable total-field magnetometer powered by solar energy.

In seismic reflection surveys, new techniques were developed with digital seismographics to apply the reflection system to shallow depths. Another interesting development in this field is optic fiber seismic cable.

A new application to both airborne and ground surveys is that of photoluminescence. Ore and indicator minerals, such as scheelite and hydrozincite, can be detected by their photoluminescence on being excited by a laser beam. The detection limit is said to be better than 0.5 percent of the exposed surface area, that is, a few hundred parts per million in uniform distribution. Scintrex Ltd., of Canada, has developed a helicopter-mounted system called "Luminex." For ground surveys, the company packaged the analyzer in a small hand-held sensor weighing about a kilogram (2.2 pounds).

In Great Britain, Harwell Laboratory made arrangements for commercial



THEMATIC MAPPER'S advantages can be seen above. Whereas **(a)** is simply a color aerial photograph of Kennecott Corporation's Safford district deposit, **(b)** shows a TMS canonically transformed image of the same area. Kennecott's alteration map is shown in **(c)**, while **(d)** is a color-coded interpretation of **(b)**.

availability of its seabed radiometric survey techniques. In measuring natural radioactivity from uranium, thorium and potassium, the system is expected to aid in exploration for such minerals as monazite, phosphate, etc.

Research is continuing on other new geophysical exploration methods, including spectral reflectance and nuclear resonance.

In assaying, as in geophysical instrumentation, the use of electronics and microprocessors is resulting in the development of accurate portable analyzers. One such instrument is the Metals Analysis Probe (MAP) announced by UNC Nuclear Industries in the United States. Using the x-ray fluorescence technique, the MAP is a direct-reading instrument that can determine on-site silver content of rock down to 1.0 ounce per ton. It has been adapted for uranium and will be developed for other elements such as gold, molybdenum and tungsten. (For a feature report on the MAP, see WORLD MINING, March 1983, page 36.)

A flameless atomic absorption spectrophotometer designed for exploration field camps was introduced by Scintrex. The instrument weighs 26 kilograms (57 pounds) and can directly analyze most water samples without pre-treatment.

New developments in drilling include lightweight core drills such as the Mole DD2 from Marlowe Drilling in the United Kingdom, and the B-24 Surveyor from Mobile Drilling Company Inc. in the United States. Both are hydraulically powered, and the Mole DD2 can be considered "man-portable" in component form. Of interest, too, is Wink's Vibra-Corer overburden sampling drill, which uses sonic vibrations instead of diamond bits for penetration. At the other end of the drilling spectrum, Boart's Seco S-3000 is claimed to be the world's largest slimhole drill, with the capability to drill a BX hole to 13,000 feet (4,000 meters) deep.

A new deep drill hole surveying instrument using an inertial navigation system was announced by Sandia Laboratories. An adaptation of aircraft navigation systems, it uses gyroscopes and accelerometers mounted in a 4-inch (100-millimeter) diameter probe. Accuracy and speed far exceed conventional systems for surveying a 10,000-foot (3,000-meter) deep hole.

Iron, Steel, and Alloys

The iron and steel industry, a leading indicator of worldwide economic activity, suffered severely in 1982. World crude steel production, nominally down in 1981, plummeted 9.1 percent to about 644,000,000 metric tons in 1982, with most of the decline in the western industrialized nations. For the United States, production decreased 38 percent, and 12 percent for the European Economic Community (EEC). Japan's production was off 2 percent, while the Soviet Union maintained its relatively steady output of recent years at about 147,000,000 to 149,000,000 metric tons.

Only two significant steel producing countries showed an increase in production: Taiwan with 30 percent, and South Korea with 9 percent.

New developments in iron ore and other ferrous metals were confined to the developing world. Of these, Brazil's megaproject, Carajás, stands out as probably the single biggest minerals project in the world. This 4,000-square kilometer (1,500-square mile) region in Para state in northern Brazil is estimated to contain vast amounts of iron and manganese ore, plus significant potential for bauxite, copper, and nickel.

The iron ore project, under Companhia Vale do Rio Doce (CVRD), the state-owned producer, is estimated to require an investment of $4,900,000,000, of which about 75 percent has been arranged. The project is stated to have 18,000,000,000 tons of hematite reserves at 66 percent iron content.

Originally planned to go into production at 15,000,000 metric tons per year in 1985, the depressed state of the iron ore business forced a slowdown in Carajás' development. Startup has been rescheduled for 1986, at about 5,000,000 metric tons, rising to 20,000,000 metric tons in 1987 and to full capacity of 35,000,000 metric tons in 1988. (For a feature report on Carajás, see WORLD MINING, January 1983, page 50.)

CVRD was selected in 1982 to develop the Igarape Azul manganese deposit only 6 miles (10 kilometers) from the iron ore deposits. Reported reserves are

MINERALS PROJECT in the Serra dos Carajás mountains of Brazil will start up in 1985, to mine iron, manganese, bauxite, copper, nickel, molybdenum, gold, silver, and uranium.

45,000,000 tons at 42.2 percent manganese, about a third of which is detrital. Annual production of between 500,000 and 1,000,000 tons per year is tentatively scheduled for 1985. Other manganese deposits in Carajás include Utah International's (ex-United States Steel) Buritirama deposit, with 12,000,000 tons at 47 percent manganese.

Also in Brazil, Minas da Serra Geral S. A., a joint CVRD-Japanese venture, brought its Campanema iron ore mine on-stream with a planned capacity of 12,000,000 tons of ore per year.

Iron ore developments in Africa included projects in Guinea, Senegal, Cameroon, Niger, and Nigeria. Engineering continued on the Mifergui Nimba Company project in Guinea's extension of Liberia's Nimba mountain range. Reserves are 500,000,000 tons of 66.7 percent iron ore, and production is visualized at 16,000,000 tons a year. (For a feature report, see WORLD MINING, December 1982, page 66.)

In Senegal, feasibility studies proceeded on Miferso's Faleme iron ore mining complex, which is estimated to require $800,000,000 for development. Reserves are estimated at 340,000,000 tons of hematite and 200,000,000 tons of magnetite ore. Production plans call for 13,200,000 tons per year.

Niger's Say oolitic deposits, not far from Niamey, were investigated by the United Nations. In Nigeria, a new iron ore deposit, estimated to contain some 2,000,000,000 tons of ore, was discovered on the Agbaja Plateau. Cameroon announced that it will proceed with mine development at its iron ore deposits near Kribi with about 130,000,000 tons of reserves.

In Canada, Borealis Exploration continued drilling on its Melville Island, Northwest Territories (NWT), magnetite property north of the Arctic Circle where some 4,000,000,000 tons of resources have been indicated in several deposits. Conceptual plans are being examined to produce 8,000,000 tons per year of plus-62 percent Fe magnetite material in 1987 in a project costing $C485,000,000 ($388,000,000).

Australia, while managing to increase iron ore production slightly in 1982, saw sharp cutbacks in Japanese purchases. The major development of a new iron ore mine in the Pilbara region appears to have been postponed indefinitely. Cliffs Robe River Iron Associates commenced mining its East Deephole deposit to replace their now exhausted Pannawonica mine. Discussions were held with the Italian steelmaker, Finsider, to establish an integrated sponge iron and steel project based on Western Australian ore.

Magnetite mining, at a rate of 14,000,000 tons per year, was announced for Iran's Golgohar deposit near Sirjan. Reserves are estimated at 200,000,000 tons.

Manganese production was down in 1982 as western nations, particularly the United States, cut back sharply on imports to reflect reduced steel production requirements. Ore prices dropped sharply as the producing countries competed for market share. A manganese nodule field was discovered by Samim in the Tyrrhenian Sea between Italy and Sicily; 2 to 3 kilograms of nodules occur per square meter, and these grade about 40 percent manganese.

Chrome, a major ingredient in stainless steel, followed a similar trend to that of manganese. Even with sharp production cutbacks, chrome ore prices slid sharply through the year. In India, the Ferro-Alloy Corporation has announced that it plans to produce charge chrome from low-grade (40 to 42 percent Cr_2O_3) friable ores. Indian reserves of this type of ore are estimated to be at about 150,000,000 metric tons.

On Luzan, in the Philippines, construction started on a joint expansion program by Benguet Consolidated Inc. and Consolidated Mines Inc. at the Masinloe property, and exploration continued in Zambales province.

From the Persian Gulf came news of a chrome discovery in the Fujairah Mountains.

Production of other ferro-alloy metals was similarly affected by the decrease in steel output. More than 60 percent of the world's vanadium is produced as byproduct or coproduct, however, and lack of sales tended to increase producer inventory. This trend will increase as plans to extract vanadium from crude oils proceed, as well as increased production from titaniferous magnetites.

World tungsten production, largely influenced by China with 25 percent of production and 50 percent of reserves, decreased about 14 percent to around 23,000 tons containing tungsten, despite drastic price reductions. North American production virtually ceased, including shutdown at year's end of the Amax-controlled Cantung mine on the NWT-Yukon border in Canada.

Utah International's Springer Mine in Nevada, United States commenced production in mid-year, but closed soon after. Exploration continued, however, particularly in Canada's Selwyn tungsten belt (Yukon-NWT) where Amax proceeded with studies on its Mactung property, and its controlled subsidiary, Canada Tungsten Mining Corporation, explored its Dublin Gulch prospect.

Other companies actively exploring this tungsten belt include Union Carbide Corporation at its Kalzas Mountain property, and Hudson Bay Mining & Smelting Company at Risby.

In New Brunswick, construction progressed on the Billiton-controlled Mt. Pleasant mine, slated to come on-stream at 1,800 tons per year of tungsten oxide. The Mt. Pleasant area was the target of many tungsten exploration programs in 1982.

Other tungsten deposits being considered for development are the Amax-Billiton Hemerdon property in England, Shell's Upington discovery in South Africa, and Anschutz Mining Corporation's Chicote Grande deposit in Bolivia.

For ilmenite, Richards Bay Minerals in South Africa commissioned its new dredge and floating concentrator to treat lower grade material. From India, it was reported that 2,000,000 to 3,000,000 tons of ilmenite were discovered offshore Konkan in Maharashtra.

Molybdenum

Perhaps no other mineral commodity was as hard hit in 1982 by the worldwide economic slump than molybdenum. The effect was intensified by the fact that the preceding two-year period was one of record production. At the end of the year, the list of molybdenum producers that had shut down included just about every major name in the Western mining world—Climax, Henderson, Esperanza, Tonopah, Endako, Kitsault, Boss Mountain. United States production was down 41 percent from 1982; Canadian production was down 26 percent. At the same time, reflecting the lower costs and different economic philosophy of the less-developed but mineral-dependent world, Chile increased output 33 percent to 45,000,000 pounds. Much of this, of course, was byproduct from record porphyry copper production.

In spite of the gloomy production picture, development of several new producers appeared not to be slowed. In the United States, United States Borax's Quartz Hill project in Alaska is proceeding toward full-scale production in 1987-88 at 40,000,000 pounds of molybdenum per year capacity, about 10 percent of current total world supply. Amoco Minerals Company's Thomson Creek, Idaho, open-pit mine is scheduled to come on-stream in late 1983 at 25,000 tons per day. Molycorp Inc.'s Questa expansion project in New Mexico, an 18,000-ton per day underground mine, will start

production in 1983. Exxon proceeded with plans to bring its Mt. Hope, Nevada, property in production by 1988 with a 30,000-ton per day open-pit mine.

In Canada, exploration continued on the Amoco-Tintina Mines Red Mountain deposit in the Yukon. Within the 79,000,000 tons of reserves grading 0.22 percent MoS_2 reported previously, a deep zone grading in excess of 10 percent MoS_2 has been outlined.

Tin

Export and production controls by the major producing countries and support buying by the ITC buffer stockpile kept tin prices up. Total production from the Malaysian Peninsula fell 27 percent to 48,575 metric tons. Australia increased production 5 percent to 12,700 metric tons, and Brazil to 9,500 metric tons.

In the Far East, Burma proceeded with development of gravel pump operations in the Tenasserim region of the country. This $30,000,000 project will raise production by about 60 percent. Malaysia's $200,000,000 Kuala Langat project was apparently deferred to await better times. Activity in Thailand centered on exploration and development of offshore tin deposits. Sea Minerals, a joint Thai-Malaysian venture, is exploring the Andaman Sea off the west coast, while Offshore Mining explores along the coast near Phuket.

Australia's unusual tin deposit, Otter Exploration's Gillian property located near Cairns, Queensland, was the subject of successful metallurgical studies. The deposit was found to contain 3,000,000 to 4,000,000 tons of 1 percent tin, partly as a new rare mineral called gillianite.

Tin exploration and development was active in Brazil, where the country's largest producer, Paranapanema, S. A., commenced production at its new Pitinga mine in the Mapuere region. This area, now considered to be a major new tin province, was actively explored by Paranapanema, as well as by British Petroleum (BP). The latter company plans to spend large amounts on exploration in the area and in the Rondonia region in western Brazil, where it is a 50 percent partner in Brascan's operations. Paranapanema's stated objective is to nearly double its tin production, mainly by developing its property north of Manaus in Amazonas.

Yet another tin producing company, Mineracao Brimadinho S. A., also announced expansion plans, for dredging in Rondonia and hard rock mining in Goias.

Elsewhere, tin production increased in the United Kingdom. A major discovery at the old Redmoor Mine, abandoned for 90 years, was announced by Southwest Consolidated Resources. The deposit is described as an 80-meter (260-foot) wide, sheeted vein structure containing tin, tungsten, zinc, copper and silver values. Off the north coast of Cornwall, Marine Mining plans commercial production of tin by 1985. The necessary permission to dredge a sea floor resource estimated to contain 20,000,000 metric tons of tin-bearing material was obtained in 1982.

In Nova Scotia, Canada, Rio Algom acquired the East Kempville tin prospect from Shell and continued investigation of the reported 40,000,000 metric tons of low-grade resources. In Japan, the government Metal Mining Agency announced discovery of new tin-tungsten-copper-zinc-bearing veins at the Kuga mine on Honshu Island.

Non-Ferrous Metals

World production of mined copper declined about 5 percent, dropping to 8,560,000,000 tons in 1982, mostly due to reduced United States and Canadian output, down 28 percent and 11 percent, respectively. The major African producers, Zaire and Zambia, produced about 5 percent less at 1,120,000 tons, while output in the Soviet Union equalled that of the previous year, reaching just over 1,000,000 tons. In contrast, Chilean mined copper production jumped 14 percent to a record 1,350,000 tons, thus overtaking the United States to become the world's number one producer. Codelco, responsible for 84 percent of Chile's copper production, reported pretax profits of $440,500,000 (on revenues of $1,670,000,000), much of it due, however, to Chile's devaluation of the peso. Australian copper production, too, was up by about 10 percent over 1981.

For lead and zinc, world mine production in 1982 increased 4 and 5 percent, respectively. Major lead production increases were recorded in the United States (18 percent) and Australia (15 percent). For zinc, decreased production in the United States and Canada was made up mostly by increased production in the Far East and Australia.

Nickel mine production in 1982 worldwide was off 25 percent from 1981. Canada slashed production by about 50 percent, New Caledonia by almost 60 percent, and Australia by about 14 percent. The Soviet Union and other centrally-planned countries were able to maintain production at about 1981 levels.

Worldwide, many major base metal mining projects, especially for copper, were deferred or simply abandoned for the foreseeable future. Victims include Cerro Colorado in Panama, Toromocho, and Cerro Verde II in Peru, Enami's Andacollo and El Abra in Chile, Marcopper Mining Corporation's San Antonio in the Philippines, and Compañía Minera de Cananea's massive expansion plans in Mexico.

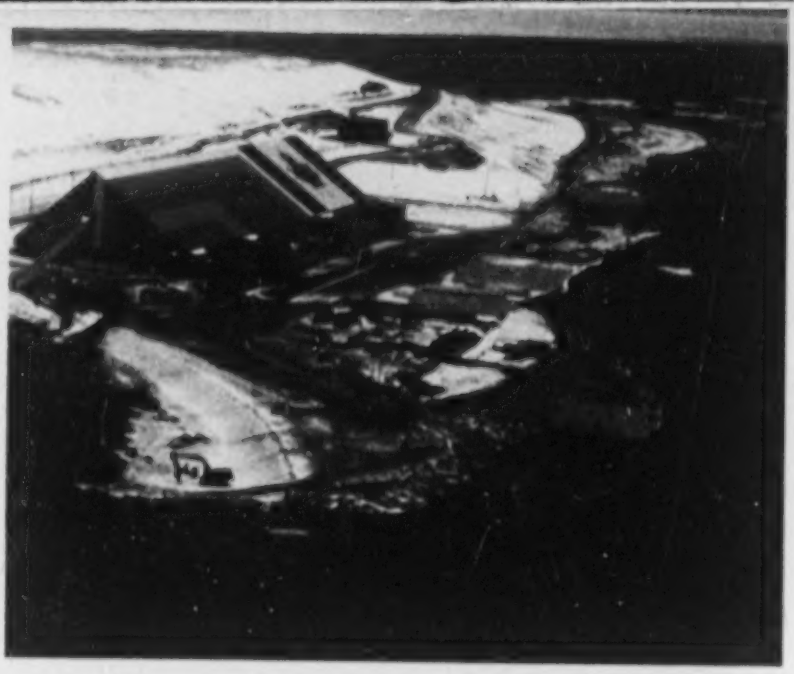
With high interest rates and long lead times, the trend is clearly towards smaller and/or higher-grade projects such as Peru's Cobriza, where expansion was completed in 1982 to 12,000 tons per day of 1.8 percent copper ore (at a capital cost of $261,000,000), and Tintaya being developed for 1984 production at 8,000 tons per day of 2 percent copper ore (capital cost—$300,000,000).

In spite of the abandoned projects mentioned earlier, Latin America saw by far the most activity in new base metal mine development and new discoveries. In Chile, the Getty-Utah International La Escondida deposit was a major focus of attention, with reserves at year-end estimated to be 420,000,000 tons at 1.92 percent copper. A large portion of the reserves are contained, mainly as chalcocite, in a secondarily-enriched zone up to 460 feet (143 meters) thick and grading significantly higher than the average grade of the deposit.

Chile Copper Company (owned by Anaconda) completed exploration of its Los Pelambres deposit, with reserves on the order of 500,000,000 tons at 0.78 percent copper. Codelco's Andina Mine division completed nearly 60,000 feet (18,000 meters) of drilling in the Sur-Sur discovery under the Riconada glacier, and estimated reserves at nearly 50,000,000 tons at about 1.8 percent Cu, including 10,000,000 tons directly below the ice that grades 2.5 percent Cu. Plans to establish an open-pit mine by late 1983 call for overburden removal that includes 2,500,000 cubic meters of ice and snow.

At Exxon's Soldado mine, plans were made to increase underground production from 3,700 to 5,500 tons per day, while, at the same time, consideration was given to an open-pit producing 23,000 tons per day. A decision on Exxon's Los Bronces mine was delayed in view of the $3,000,000,000 price tag. A smaller project, between 45,000 and 55,000 tons per day, is being studied.

Billiton reported promising preliminary results from its prospect in Huasco. Phelps Dodge entered the scene by purchasing 64.3 percent of Compañia Minera Ojos del Salado, a Chilean company



POLARIS, Cominco's lead-zinc mine on Little Cornwallis Island in northern Canada, reached full production despite permafrost.

owning several small copper-gold properties in the Punta del Cobre mining district.

Peru, in addition to the Cobriza expansion and Tintaya development, saw inauguration of the Monterrosas mine of Compañia Minera los Montes. This 1,000-ton per day underground mine has reserves of 1,500,000 tons containing 1.7 percent copper and 0.04 ounce gold per ton.

Centromin, despite the Cerro Verde II setback, proceeded with the Andaychagua expansion project. The group also reported a copper-cobalt discovery at Sur Chico on the south coast.

Minero Peru investigated private participation, both local and foreign, to develop its Antamina copper-zinc-silver deposit for 11,000 tons per day mine production, but with little success. Other Minero Peru news included announcement of plans for a feasibility study for the Tambo Grande deposit with reserves of 42,000,000 tons at 2 percent copper, 1 percent zinc, and 1 ounce silver per ton.

The La Granja copper deposit in Cajamarca, with 230,000,000 tons containing 0.82 percent copper, was still being evaluated by a European group.

In Mexico, IMMSA completed expansion of its Santa Barbara mine to 5,400 tons per day, and development continued at Industrias Peñoles' La Minita mine.

Brazil's giant Carajás development program includes several non-ferrous metal deposits. The Salobo property is estimated to contain 1,300,000,000 to 1,800,000,000 tons at 0.83 percent copper plus molybdenum, gold, silver and uranium credits. Several major mining companies, such as Kennecott, Anaconda, and Noranda, as well as a delegation from the Soviet Union, have shown interest since Brazil opened exploration and development to private and international participation. (Copper mine development is to be encouraged as the Jaguari mine appears unlikely to supply enough concentrate to the large government-owned Caraíba Metais smelter complex.) The Carajás region has lateritic nickel deposits as well, and some 40,000,000 tons at 1.56 percent nickel is contained in two deposits at Vermelho.

Also in Brazil, Codemin, in a joint venture with Anglo American Corporation, commissioned its $100,000,000 open-pit nickel mine in the Serra da Mantiqueira, some 180 kilometers (110 miles) north of Brasilia. Production from the nickel silicate ore, grading 1.4 to 1.6 percent Ni, is expected to be between 5,000 and 6,000 tons per year contained nickel.

Colombia's $400,000,000 Cerro Matoso open-pit nickel project started operations in 1982 after 18 years of planning and development. The project, a joint venture between the government (45 percent), Billiton (44 percent) and Hanna Mining (11 percent), produces ferro-nickel. Reserves of lateritic ore are 22,000,000 tons at 2.7 percent nickel, plus 40,000,000 tons at 1 to 1.5 percent nickel. Other base metal deposits investigated in Colombia include the low-grade Pantanos-Pegadorcito copper porphyry (400,000,000 tons at 0.4 percent Cu) and Patascoy, with 200,000,000 tons at 0.8 percent copper and 0.06 percent molybdenum. To develop its mining industry, Colombia is studying a new national minerals policy.

Elsewhere in Latin America, Falconbridge Dominicana discovered a small, high-grade copper deposit near its Cerras de Maimón concession area in the Dominican Republic and is considering a joint mining project with the government for mining of 3,000,000 tons of 4 percent copper.

At El Mochito, Honduras, Rosario Resources completed expansion plans to double capacity to 2,500 tons per day of lead-zinc-silver ore.

In Canada's far north, Cominco's $140,000,000 Polaris lead-zinc mine reached full production from reserves of 25,000,000 tons at 14.1 percent zinc and 4.3 percent lead. (For a feature report on Polaris, see WORLD MINING, September 1982, page 46.) The company has announced discovery of a 2,000,000-ton orebody, grading 14 percent zinc and 7 percent lead, about 14 miles (22 kilometers) from its Pine Point concentrator.

Cominco started production from its Lake Zone copper deposit in British Columbia's Highland Valley, albeit at a much-reduced rate than had been originally planned. Reserves of 800,000,000 tons at 0.475 percent Cu make this the largest porphyry copper deposit in Canada.

Drilling at the Falconbridge-Geddes Resources Windy Craggy prospect indicated that this could be one of the largest copper-cobalt deposits in the world. Resources are estimated at 350,000,000 tons at 1.52 percent copper and 0.08 percent cobalt, plus zinc, gold and silver credits. Included in this total are about 100,000,000 tons averaging 3 percent copper. Near Dease Lake, British Columbia, Sumitomo prepared for a feasibility study on the Kutcho copper deposit. Reserves here are 17,500,000 tons containing 1.57 percent copper, 2.38 percent zinc, and close to 1.0 ounce per ton (34 grams per metric ton) silver.

At the Amax-funded Midway project straddling the British Columbia-Yukon border, resources at year's end were estimated to be 3,600,000 tons with 12 ounces silver per ton (410 grams per metric ton) and 19 percent combined lead and zinc.

Continued drilling at Aberford Resources' Jason property in the Yukon confirmed reserves of 15,500,000 tons containing 7.1 percent lead, 6.6 percent zinc and 2.33 ounces silver per ton (80 grams per metric ton).

Falconbridge explored the Winston Lake property in northwestern Ontario under an option from Zenmac Explora-

tions, and then announced reserves of 3,000,000 tons grading 13.5 percent zinc, 1 percent copper, plus silver and gold.

Riocanex drilled at its Chibougamau, Quebec prospect and estimated the resources of 2,000,000 tons, containing 4.25 percent copper plus precious metals.

In Manitoba, a consortium led by Hudson Bay Mining and Smelting started production from the Trout Lake deposit near Flin Flon at about 2,000 tons per day from reserves of 3,300,000 tons grading 3 percent copper, 4.5 percent zinc, 0.40 ounce silver per ton (13.7 grams per metric ton) and 0.04 ounce gold per ton (1.4 grams per metric ton).

From Newfoundland, Noranda reported a significant copper-zinc-silver discovery at Tally Pond.

United States base metal development activity was limited with exploration programs severely cut back. Two important new mines came on-stream: the Copper Flat copper mine near Hillsboro, New Mexico, and the Pierrepont zinc mine in upper New York state. Copper Flat, jointly owned by Quintana and Phibro, is a 15,000-ton per day open pit with 60,000,000 tons of reserves grading 0.42 percent copper and 0.012 percent molybdenum, with minor gold and silver credits. However, like other United States copper mines, it, too, experienced shutdowns in 1982. Pierrepont, owned by St. Joe Resources, is an underground mine producing 500 tons per day of ore from 2,600,000 tons of reserves averaging 16 percent zinc. (For a feature report on Pierrepont, see WORLD MINING, March 1983, page 58.)

Work continued at Cominco's Red Dog zinc-lead-silver deposit in Alaska, $C11,000,000 ($8,800,000) being spent on detailed evaluation. The preliminary plan is to start construction on a 3,000-ton per day operation in mid-1984 using a pre-assembled modular plant with the facility to double the production rate later. Also in Alaska, Anaconda acquired a one-third interest in Noranda's Green's Creek lead-zinc-silver-gold project on Admiralty Island.

In New Mexico, Boliden started development of the Pinos Altos property, where Exxon had found about 7,000,000 tons of reserves grading 2 percent copper and 3 percent zinc. Mine development commenced at Silver King Mines' Ward property in Nevada towards a 1,000 tons per day operation in 1985. Reserves are 5,000,000 tons at 1.2 percent copper, 4 percent combined lead-zinc, and 3 ounces silver per ton (100 grams per metric ton).

Ni-Cal Developments Ltd. commissioned a feasibility study for its Gasquet Mountain, California nickel deposit.

After 3 years' detailed exploration work on the Olympic Dam discovery near Roxby Downs, South Australia, Western Mining Corporation and BP announced a reserve estimate totalling 2,200,000,000 tons averaging 1.6 percent coppper, 0.06 percent U_3O_8 and 0.02 ounce gold per ton (0.6 gram per metric ton). Preliminary plans call for a $1,000,000,000 mining project to start production in the mid-1990's. The joint venture discovered significant copper mineralization in a geologic environment similar to Olympic Dam, at the Wirrda Well prospect 13 miles (21 kilometers) away.

Other major developments in Australia include Mt. Isa's start on its expansion to boost lead production by 20 percent; a production startup at the EZ Industries' Elura lead-zinc mine in New South Wales, where reserves amount to 30,000,000 tons at 8.3 percent zinc, 5.6 percent lead and 4 ounces silver per ton (137 grams per metric ton); and EZ Industries' upgrading of reserves at its Scuddles deposit near Golden Grove in Western Australia to 20,000,000 tons containing 9.5 percent zinc, 2.3 ounces silver per ton (78 grams per metric ton), plus copper and gold values.

Elsewhere, St. Joe Minerals made a deal to explore and participate in the Sorby Hills prospect, where 15,000,000 tons of reserves grading 5.4 percent lead and about 2 ounces silver per ton (70 grams per metric ton) have been estimated. In New South Wales, Chevron has taken a stake in Peko-Wallsend's Parkes porphyry copper discovery, reported to contain 250,000,000 tons at 0.7 percent copper.

Developments in Papua New Guinea include Broken Hill Proprietary's discovery of a deposit in the Western Highlands similar to Ok Tedi in size and grade, and Placer's continued work at Porgera where the most likely plan under consideration appears to be selective mining of higher-grade zones. Meanwhile, development of Ok Tedi fell behind schedule as an unusual drought disrupted barge traffic on the Fly River from the coast.

In the Philippines, North Davao's Amacon copper project came on-stream. Lepanto Mining formed a joint venture with the government to develop the Hinobaan open-pit mine on Negros Island. Reserves are 100,000,000 tons at 0.40 percent copper, and startup is scheduled for 1984.

Freeport Indonesia continued expansion of its Ertsberg mine production from 9,500 to 12,000 tons per day by 1984. The Ertsberg East underground mine achieved targeted production of 6,000 metric tons per day in early 1983, and drilling of the deep, high-grade mineralization to develop additional reserves proved successful.

India's largest open pit copper mine, Malanjkhand in Madhya Pradesh state, commenced production in mid-1982. Reserves of 60,000,000 metric tons grading 1.3 percent copper will be mined at the rate of 2,000,000 metric tons a year. The government-controlled Hindustan Zinc Ltd. (HZL) announced reserves for the Rampura-Agucha deposits as 67,000,000 tons with 15 percent combined lead-zinc. A feasibility study is under way. HZL is also studying the feasibility of the Baroi Mine in Rajasthan, where reserves of 7,700,000 tons at 3.85 percent lead and 1.22 percent zinc have been established.

In neighboring Pakistan, a feasibility study for the Saindak copper deposit in Baluchistan was commenced with Canadian help. Resources are 450,000,000 tons of low-grade ore.

A major development in Asia is the Erdenet open-pit copper-molybdenum porphyry mine in Mongolia near the Soviet border. Full capacity of 44,000 tons per day was expected by the end of 1982. Reserves, mainly in a supergene blanket, are 300,000,000 tons at 0.85 percent copper and 0.12 percent molybdenum. (For a feature report on Erdenet, see WORLD MINING, October 1982, page 58.)

In the Middle East, the Sohar copper mining and processing complex in Oman was completed and officially started up in January 1983. Underground mining is from two ore bodies, Lasail and Bayda, with a third deposit, Aarja, to be developed as reserves of the first two become depleted. Full-scale production will be about 4,000 tons per day of ore. These deposits occur as pipe-like structures in ophiolitic volcanics and total reserves are 13,000,000 tons at 2 percent copper.

Saudi Arabia continued its widespread minerals exploration program, on the Arabian Shield as well as in the Red Sea deeps. At Khnaiguiyah-Al Amar, several deposits were identified and estimates of reserves total 13,000,000 tons at 5.3 percent zinc and 0.34 percent copper plus silver. In the Atlantis II deep in the Red Sea, the joint Saudi-Sudanese venture outlined a deposit covering 25 square miles (65 square kilometers), and varying in thickness from 7 to 100 feet (2 to 30 meters). The deposit is covered by about 650 feet (200 meters) of brine un-

der approximately 6,500 feet (2,000 meters) of seawater. Metal content is estimated at 2,000,000 tons of zinc, 450,000 tons of copper and 100,000,000 ounces (3,000,000 kilograms) of silver. Feasibility studies are continuing with West German assistance. (For a feature report on Saudi exploration, see WORLD MINING, October 1982, page 126.)

European developments included increased exploration activity in Spain by local companies, as well as Exxon, Phelps Dodge, Newmont, Charter, and Billiton. A significant lead-zinc discovery was reported from eastern Leon province, and Exminesa (48 percent Cominco) was granted a mining concession for its Troya deposit in Guipuzca Province. Feasibility studies are now considering a 1,000-ton per day operation from 5,500,000 tons of lead-zinc ore.

Portugal's Neves Corvo deposit, a high-grade complex copper-lead-zinc-silver body in the Alentejo pyrite district, underwent feasibility studies towards production of 4,000 metric tons per day of 6 percent copper ore by 1985-86. The project is a joint venture between the government and Penarroya and BRGM. Billiton, too, will explore in the Alentejo district.

In Ireland, Bula Mines reached agreement with local authorities to proceed with development of its underground lead-zinc mine at Navan, County Meath. The planned production is 660,000 tons of ore per year.

Finland's Outokumpu Oy carried out investigations of the huge, but low-grade resources in the black schists at Sotkamo, eastern Finland. Average grade of some 300,000,000 tons of material is estimated to be 0.52 percent zinc, 0.26 percent nickel, and 0.14 percent copper plus cobalt. A leach pilot plant to investigate the difficult metallurgy was completed at Outokumpu in 1982.

In Turkey, Phelps Dodge started drilling the Cayeli copper-zinc deposit and intersected some 300 feet (90 meters) of massive sulphides grading 10.2 percent zinc, 3.3 percent copper, 1.93 ounces silver per ton (66 grams per metric ton), and 0.04 ounce gold per ton (1.3 grams per metric ton). The Turkish Mineral Research and Exploration Institute estimates reserves on the order of 30,000,000 tons.

Yugoslavian projects under investigation or development in 1982 included the Veliki Krivelj copper mine, 160 kilometers (100 miles) southeast of Belgrade, which came on-stream at a rate of 8,000,000 metric tons ore per year; pilot plant testing at the Suplja Stijena lead-zinc project in Montenegro; and discovery at Prijepolje, southwest of Belgrade, of 3,000,000 metric tons of high-grade copper-zinc-gold ore.

In Greenland, Cominco started development of its Marmorilik Plateau lead-zinc deposits, which lie about 4 kilometers (2.5 miles) from its current Black Angel mining operations.

On the African continent, Société Arabe des Mines de l'Inchiri evaluated reopening the Akjoujt mine in Mauritania, formerly operated by Somina. Reserves of 100,000,000 tons at 2.25 percent copper are reported to contain major gold values. In Botswana, exploration delineated significant additional resources of copper-nickel at Pikwe-Selebi. Newmont's Carolesberg, South Africa, project is expected to be in production by mid-1983 with reserves of 15,000,000 metric tons at 1.99 percent Cu.

Gold and Silver

World gold production in 1982 totalled 41,000,000 ounces (1,275,000 kilograms), almost identical to 1981's output of 40,750,000 ounces. Price was very volatile, ranging from below $300 to near $500 an ounce, with some drastic short-term swings.

For silver, production at 364,000,000 ounces (11,320,000 kilograms) was fractionally down from 1981, no doubt reflecting the decline in byproduct output by the large North American porphyry coppers. The silver price closely followed that of gold, ranging from below $3.00 to over $11.00 an ounce.

Exploration and development continued apace worldwide for these two precious metals, including new discoveries, expanded reserves, and testing and retreatment of old dump material.

South Africa. South Africa accounted for about 52 percent of world gold output in 1982, including 68 percent of the non-communist countries' production. Mined gold increased in 1982 by about 1 percent over 1981 to 21,400,000 ounces (665,500 kilograms). The average grade of gold ore mined was 0.20 ounce per ton (6.8 grams per metric ton), slightly less than in 1981. Production costs increased significantly at most mines, due to higher energy costs and income tax surcharges.

Capital expenditure on gold developments over the next five years is estimated at $4,500,000,000 by the South African Chamber of Mines. Shaft sinking continued at Anglo American Corporation's Erfdeel-Dankbaarheid property near Welkom, for scheduled production in 1987 at 225,000 metric tons ore per month. A new shaft will be sunk at Anglo American's President Brand mine for mining the northern section of the orebody and to extract a high-grade shaft pillar around the current main shaft.

The Hartebeestfontein Gold Mining Company announced new reserve figures of 14,650,000 metric tons at 12.3 grams per metric ton (0.36 ounce per ton). Anglo-Vaal's 3 ETL mines listed reserve figures of 1,420,000,000 metric tons at an average grade of 10.7 grams per metric ton (0.31 ounce per ton). Rand Mines and Johannisberg Consolidated Investment Company Ltd. (JCI) announced successful results of the exploration program at Vermeulenskraal, adjoining Harmony Gold Mining's operation. Plans call for milling the ore at Harmony.

Exploration in the Witwatersrand basin continued apace, with the main focus on seeking extensions to existing gold districts. Near the Randfontein Mine, south of South Roodepoort, JCI completed feasibility studies showing economic mining to be possible if the deposits were an integral part of Randfontein, due to tax considerations.

Anglo American, too, obtained gold values in drilling south of the Western Areas mine in the same district. Anglo American was also very active in the Free State part of the basin, obtaining high gold and uranium values in drill intercepts in the Vaal reef south of the Vaal Reefs mine, Klerksdorp area, as well as finding mineralization in Ventersdorp Contact Reef in this district. The company continued its exploration near the Beisa and Beatrix mines. Deep exploration of the Ventersdorp Contact Reef was carried out by Gold Fields southwest of the Kloof Mine.

Other companies actively exploring in the area are Anglo American and JCI. Rand Mines obtained a lease from the City of Johannesburg to explore under that city's southern suburban area.

Increasing attention is being focused on gold (and uranium) extraction from the vast tailings accumulated in earlier mining, due to the success of Anglo American's ERGO project, brought on-stream in 1978, which is producing 193,000 ounces (6,000 kilograms) of gold plus uranium and sulphuric acid from tailings containing less than 0.8 gram of gold per metric ton (0.02 ounce per short ton). Nearly 20,000,000 metric tons are treated annually and almost half the gold content is recovered.

In addition to the original investment of R145,000,000 ($132,000,000), a carbon-in-pulp leach plant is to be constructed at a cost of R63,000,000

($57,000,000) to increase overall gold recovery to about 70 percent.

During 1982, Rand Mines initiated a R50,000,000 ($45,000,000) project to treat old tailings from its Crown Mines just outside Johannesburg. A total of 4,500,000 metric tons containing 0.5 gram per metric ton will be treated annually to produce 2,500 to 3,000 kilograms of gold, plus by-products.

There are some 3,500,000,000 metric tons of tailings in dumps from Witwatersrand mining containing an estimated $20,000,000,000 worth of gold, uranium and other metals at today's prices. It is estimated by South Africa's Council for Mineral Technology that about half of this is amenable to treatment with current technology.

The archean greenstone belt near Barberton in the eastern Transvaal remains an active exploration area, and several old properties are being examined for small-scale production.

In Zimbabwe, Rio Tinto's Renco mine came on-stream. Its production should be about 1,500 kilograms (48,000 ounces) of gold per year, from reserves of about 1,000,000 metric tons.

Many smaller mines in the country only survived the year with aid from the Gold Mining Assistance program. Other companies active in gold exploration include Lonrho and Union Carbide, the latter company doing underground exploration at its Reroro prospect near Bulawayo.

United States. The United States gold production in 1982 was 1,230,000 ounces (38,250 kilograms), down from 1981's 1,380,000 ounces. Silver production, at 35,100,000 ounces (1,100 metric tons), was significantly below 1981's 40,700,000 ounces. These figures reflect reduced precious metals byproduct output from base metal mines shut down or operating at much reduced rates.

Among major gold developments, Homestake Mining Company proceeded with its McLaughlin mine development 90 miles (145 kilometers) north of San Francisco, which is scheduled for mid-1985 startup at 3,000 tons per day from reserves of 20,000,000 tons at 0.16 ounce gold per ton (5.5 grams per metric ton). Elsewhere in California, near Marysville, Yuba Placer Gold Company has commenced dredging aimed at producing 21,000 ounces (650 kilograms) of gold from approximately 4,000,000 cubic yards (3,000,000 cubic meters) of material annually.

In Imperial County, Gold Fields Mining Corporation announced discovery of a large tabular body estimated to contain 26,000,000 to 40,000,000 tons grading between 0.056 and 0.075 ounce gold per ton (1.9 to 2.5 grams per metric ton). A discovery in Plumas County was reported to contain 3,300,000 tons at 0.13 ounce gold per ton (4.4 grams per metric ton).

In Montana, Placer Amex commissioned its Golden Sunlight property 36 miles (58 kilometers) east of Butte at year's end. This large, open pit gold mine was brought in well ahead of schedule and under budget. Its reserves of 25,800,000 tons at 0.05 ounce per ton (1.7 grams per metric ton) will be mined at a rate of 5,000 tons per day to produce 72,300 ounces (2,250 kilograms) of gold per year.

Mineralization occurs where a silicified breccia zone in a Precambrian sedimentary sequence is cut by a set of high-angle fractures, with gold, pyrite and associated minerals (chalcopyrite, sphalerite, molybdenite, and barite) both in the fractures and disseminated in the host rock.

With precious metal exploration activity at a high level, Nevada saw several important developments. Duval Corporation, which in 1981 announced discovery of additional gold and silver ore at its Battle Mountain properties, stepped up production to 40,000 tons per day of ore and waste, or 120,000 tons of ore per month. Mill feed grade is 0.065 ounce gold per ton (2.2 grams per metric ton), but lower grade material is also leached. Production is 80,000 ounces (2,500 kilograms) of gold per year plus silver. Reserves are reported to contain 2,700,000 ounces (84,000 kilograms) of gold and 62,800,000 ounces (1,950 metric tons) of silver.

Overburden stripping at the new discovery, to be called the Fortitude Mine, adjacent to current operations, commenced for a planned production start in 1985. Reserves are 16,000,000 tons at 0.15 ounce gold per ton (5.1 grams per metric ton) gold and 0.57 ounce silver per ton (19.5 grams per metric ton).

New developments in Nevada include the discovery of at least 1,000,000 tons of ore in a flat-lying quartz vein at the old Victorine property, south of Austin; discovery by Pyramid Resources of the Sphinx Zone, containing 1,500,000 to 2,000,000 tons of ore at its Bell Mountain gold-silver mine; and Lacana's Relief Canyon deposit, 100 miles (160 kilometers) northeast of Reno, estimated at 5,000,000 to 10,000,000 tons grading about 0.05 ounce gold per ton (1.6 grams per metric ton).

At the Freeport-FMC Jerrit Canyon mine, additional reserves of 1,500,000 tons at 0.15 ounce gold per ton (5.1 grams per metric ton) were found in 1982, closely paralleling production for the year. Total reserves at the end of 1982 were 11,614,000 tons at 0.233 ounce gold per ton (8 grams per metric ton).

Newmont proceeded with development planning for its Gold Quarry deposit, expected to produce 120,000 ounces (3,700 kilograms) of gold per year in the mid-1980's. Latest reserve figures are 25,000,000 tons at 0.11 ounce per ton (3.6 grams per metric ton), plus there is a low-grade zone of 150,000,000 tons at 0.04 ounce per ton (1.2 grams per metric ton).

The Rain deposit, 20 miles (30 kilometers) south of Gold Quarry, has reported reserves of 8,250,000 tons at 0.08 ounce per ton (2.85 grams per metric ton). Placer Amex prepared its Horse Canyon deposit, with 3,400,000 tons at 0.06 ounce gold per ton (2 grams per metric ton), for 1983 production.

Further north, in Washington, Asamera Inc. expanded the size of its Saddle Mountain deposit near Wenatchee in a continuing program of exploration.

Getty's Mercur project in Tooele County, Utah proceeded towards initial production in mid-1983. Scheduled output is 80,000 ounces gold per year from 15,000,000 tons of reserves grading 0.10 ounce per ton (3.4 grams per metric ton).

Wharf Resources' Annie Creek project in South Dakota is scheduled for startup in mid-1983, leaching 500,000 tons annually from reserves of about 6,300,000 tons containing 0.043 ounce gold per ton (1.5 grams per metric ton).

As regards silver, low prices in the first half of the year plus the closure and sale of the Bunker Hill operations brought depression era conditions to Idaho's Coeur d'Alene district. By year's end, however, production was up, accounting for 44 percent of total United States silver production. Shaft deepening and/or new shaft sinking were in progress or planned by several companies, while on the exploration front, Anaconda continued its investigation of a possible extension of the silver belt southeast of Wallace.

Asarco's Troy, Montana, mine completed its first full year of production in 1982 with an output of 4,200,000 ounces silver to become the number one producer in the United States. Reserves are about 60,000,000 tons at 1.54 ounces silver per ton (53 grams per metric ton) and 0.74 percent Cu. About 20 miles (30 kilometers) from Troy, the Rock Creek project was Asarco's major exploration effort for the year. Grade is suspected to

DRILLING at Dome/Amoco joint venture at Detour Lake Project, Ontario, Canada. Open pit production will commence in 1983.

be higher than Troy, and an intensive helicopter-supported drilling program using seven drills is planned for 1983.

Nevada silver developments included the startup of Sunshine Mining Company's Sixteen to One mine, scheduled to produce 1,250,000 ounces (38,900 kilograms) of silver plus 4,000 ounces (120 kilograms) of gold annually. Near Ely, Silver King Mines is planning to develop its Ward property with 5,000,000 tons containing 3 ounces silver per ton (100 grams per metric ton), plus copper, lead and zinc.

In Colorado, Pioneer Corporation took over exploration of the Creede properties abandoned last year by Chevron Resources, and plans to concentrate on the high-grade zones found by Chevron.

Canada. Canadian gold production in 1982 of 1,800,000 ounces (56,000 kilograms) was 20 percent greater than the previous year. Silver production was about 41,000,000 ounces (1,275 metric tons), up 6 percent from 1981.

Of major significance was the Hemlo "gold rush." This area, located on the north shore of Lake Superior in southwestern Ontario, made news in 1981 with the discovery by Corona Resources of significant gold mineralization in metamorphosed Precambrian volcanoclastic sedimentary rocks. Although the area has a history of gold exploration and discovery dating back to 1947, the past year saw the staking of many thousands of claims, the entry of major companies and numerous announcements of discoveries and developments. Noranda Mines Ltd., which acquired the properties of Goliath Gold Mines and Golden Sceptre Resources, and, jointly with Teck Corporation, the Interlake property, provided the main excitement and stimulus.

Noranda has advanced to the stage of planning a $C40,000,000 ($30,000,000) shaft to a depth of 2,800 feet (850 meters), and has reached agreement with neighboring claim owners, Corona and Teck, regarding the location and use of this shaft. Noranda is aiming at production from it by November 1984, and a $C300,000,000 ($240,000,000) milling facility is part of the plan.

It is estimated that the three largest land holdings, Goliath-Golden Sceptre, Corona, and Lac Minerals, contain some 20,000,000 tons of ore at an average grade of about 0.25 ounce per ton (8.5 grams per metric ton). The outstanding feature of these gold deposits is the continuity of mineralization and grade, along strike as well as with depth, suggesting that they may be of syngenetic sedimentary origin.

Elsewhere in Ontario, Queenston Gold Mines has arranged with Inco for the development of the McBean open-pit gold mine near Kirkland Lake. Ore grade is 0.15 ounce gold per ton (5.1 grams per metric ton).

Dome Mines Ltd. continued its expansion project at the South Porcupine mine to raise production to 3,000 tons per day by the end of 1984. Dome and Amoco progressed with the development of their Detour Lake mine. Production from the open pit will commence in late 1983 at 2,500 tons per day and will be augmented by underground mining to produce a total of 4,000 tons per day by 1987. At Sturgeon Lake, where Steep Rock Iron Mines located gold-bearing veins, extensive claim staking took place.

Gold exploration was very active in Quebec, where a total of $C64,300,000 ($51,400,000) was expended on the search. In the Val d'Or district, the Falconbridge-Soquem joint venture found significant mineralization on the New Pascalis property. Several companies are actively exploring the area, including Long Lac and Sigma. Near Rouyn, Aiguebelle Exploration is bringing in its Destor mine with reserves of 2,240,000 tons at 0.175 ounce gold per ton (6 grams per metric ton).

At its Bousquet-Cadillac property, Dumagami Mines Ltd. completed plans for a 1,000-ton per day operation with reserves of 2,500,000 tons at 0.09 ounce gold per ton (3 grams per metric ton), plus silver and copper values. Startup is planned for early 1985. Near Desmaraisville, the Bachelor Lake mine came on-stream in mid-year, with eventual production planned at 32,000 ounces (1,000 kilograms) gold per year from about 1,000,000 tons of reserves at 0.185 ounce per ton (6.3 grams per metric ton). The Montauban property of Muscocho-Soquem will commence production in 1983 from reserves of 1,000,000 tons grading 0.122 ounce per ton (4.2 grams per metric ton).

In British Columbia, detailed drilling on the Granduc Mines-Esso Sulphurets property north of Stewart found extensive gold-silver mineralization. Other precious metal exploration activity in the province includes the Sylvester K discovery near Greenwood, the Tillicum Mountain area near Lower Arrow Lake, the Quesnel River deposit of Dome-Orbex, Cominco's Fish Lake property, Valentine Mountain on Vancouver Island, and the Aslin area.

On the Queen Charlotte Islands, Consolidated Cinola completed a feasibility study for its low-grade Specogna gold property, which has reserves of 30,000,000 tons at 0.06 ounce per ton (2 grams per metric ton). The old Bralorne Mine, inactive since 1971, is also being considered for production after an exploration program by E&B Exploration showed about 1,000,000 tons at 0.25 ounce gold per ton (8.5 grams per metric ton) remaining in the upper levels of the mine. In the Toodoggone area, sizeable expenditures were made by Kidd Creek, Serem and others on the silver-gold showings there.

The Northwest Territories saw the startup of the Lupin Mine at Contwoyo Lake, 250 miles (400 kilometers) northeast of Yellowknife. Production is about 1,000 tons per day from reserves of 3,500,000 tons at 0.36 ounce gold per ton (12.3 grams per metric ton), yielding 140,000 ounces (4,400 kilograms) of gold per year. Another new NWT mine is Cullaton Lake, in production at 300 metric tons per day, but also being developed for greater output. Giant Yellow-

knife Mines plans to proceed with development of its Salmita gold property.

Across Canada other precious metals developments of note include Flin Flon Mines Ltd.'s planned production from its Saskatchewan property by late 1983; shaft deepening by Sherritt Gordon Mines Ltd. at its Agassiz property in Manitoba, where reserves were reported to be 2,000,000 tons at 0.14 ounce gold per ton (4.8 grams per metric ton); and discovery of various silver-bearing base metal deposits in the Yukon Territory.

Australia and New Zealand. Australian gold production jumped by 50 percent in 1982, with a total mine output of 880,940 ounces (27,400 kilograms) in 1982. As has been the pattern in recent years, gold exploration and development activity remained at a high level, particularly in Western Australia. Australia's silver output was increased by about 9 percent to 28,000,000 ounces (870 metric tons).

Western Mining Corporation produced 290,840 ounces (9,000 kilograms) in its 1981-82 financial year, some 63 percent higher than the previous year. At its Victory property south of Kambalda, reserves were increased to 4,750,000 tons at 0.14 ounce gold per ton (4.7 grams per metric ton). Open pit development is proceeding and underground production will commence in 1983. Reserves at the Lancefield gold operation, jointly owned by Western and Shell, were increased to 500,000 tons grading 0.18 ounce per ton (6.2 grams per metric ton).

Near Kalgoorlie, the CSR-Hampton Areas joint venture is developing the Paringa property for production at 140,000 tons per year by mid-1983. Grade is about 0.25 ounce gold per ton (8.5 grams per metric ton). The Newmont-Hampton venture found shallow resources of 2,000,000 tons grading 0.10 ounce gold per ton (3.5 grams per metric ton). Pancontinental Mining's Paddington property was announced to have reserves of 5,830,000 tons containing 0.09 ounce gold per ton (3.1 grams per metric ton), of which about 4,000,000 tons can be mined by open pit. Preliminary plans call for a production rate of 500,000 tons per year.

Still in the Kalgoorlie area, Freeport of Australia found about 5,000,000 tons grading 0.11 ounce gold per ton (3.9 grams per metric ton) at its optioned Karonie property. Occidental Australia, too, found gold mineralization in this district, with drill intercepts grading 0.04 to 0.36 ounce per ton (1.5 to 12.4 grams per metric ton). At the Harbour Lights prospect of Carr Boyd Minerals-Esso, gold mineralization averaging about 0.25 ounce per ton (8.5 grams per metric ton) was found in several drill holes. Australian Consolidated Minerals' Big Bell deposit increased reserves to 11,300,000 tons, grading 0.15 ounce gold per ton (5.1 grams per metric ton). Asarco agreed with Metramar Minerals to continue to explore the latter company's property near Wiluna, on which Asarco has already spent $A2,000,000 ($1,800,000).

Elsewhere, Renison Goldfields reported 5,600,000 tons grading 0.10 ounce gold per ton (3.4 grams per metric ton) at the Enterprise Gold Mines prospect at Pine Creek in the Northern Territory. In the Tanami desert, Northern Territory, North Flinders Mines examined alternative production programs for its Granites gold deposit. Amoco continued active at its Selwyn Hematites and Mungana projects in Queensland.

New Zealand's gold exploration continued its 1981 pace, with the Martha Hill property near Waihi on North Island the main center of activity. Reserves are estimated at 16,000,000 tons grading 0.09 ounce gold per ton (3.1 grams per metric ton) and 1 ounce silver per ton (34 grams per ton). Open pit mine planning is under study. Offshore South Island, CRA reported discovery of a large area of gold-bearing gravels.

Other Countries. Gold and silver developments were reported from many countries worldwide. Sumitomo's discovery on Kyushu Island, announced in 1981, is being developed as Japan's largest gold producer. Reserves contain 3,600,000 ounces (112,000 kilograms) of gold at 2.3 ounces per ton (80 grams per metric ton), and production rate will be 220 tons per day.

In Latin America, Brazil's Serra Pelada small worker district was a major contributor to the country's 1982 "official" gold production of 916,000 ounces (28,500 kilograms), an increase of 64 percent over 1981. ("Unofficial" production could raise production figures by 50 percent or more.)

Mineracao Morro Velho S. A. (controlled by Anglo American) completed expansion of the Jacobina mine in Bahia Province to 22,000 tons per month. The company plans to reopen the Cuiaba mine at Sabana, Minas Gerais, for production of 160,000 ounces (5,000 kilograms) of gold per year from 1986. The company's Raposos property, also in Minas Gerais, will produce 48,000 ounces (1,500 kilograms) of gold from 1988 onwards. Morro Velho's 1983 gold exploration budget is $2,500,000. Elsewhere in Brazil, exploration continued at the Araci prospect in Bahia, and the Crixa deposit in Goias.

In Chile, St. Joe Minerals announced gold reserves for El Indio as 4,700,000 tons at 0.30 ounce per ton (10.3 grams per metric ton).

Peru plans to increase silver production significantly. During 1982, Asarco expanded capacity at its Quiruvilca mine by 50 percent to 1,500 tons per day, to produce in excess of 2,000,000 ounces (68,600 kilograms) of silver per year from reserves of 4,700,000 tons at 5.8 ounces silver per ton (200 grams per metric ton), 1.4 percent Cu, 3.3 percent Zn, and 1.2 percent Pb.

The Central America-Caribbean region had a number of active gold projects in 1982. In the Dominican Republic, the United Nations agreed to provide technical assistance to the government in a three-year program to evaluate the Miches alluvial gold deposit. The major development in the country was completion of Rosario Dominicana's refinery at Pueblo Viejo. Next door, in Haiti, gold mineralization resembling Pueblo Viejo was discovered near Milot in the north. The small oxide capping grades 0.1 ounce per ton (3.2 grams per metric ton) and is underlain by sulphide mineralization similar to that at Pueblo Viejo. Development is planned with United Nations Revolving Fund assistance.

The Santa Clara gold mine in Costa Rica, operated by United Hearne Resources of Canada, is gradually expanding to full production of 3,000 tons per day. Reserves are reported as 4,400,000 tons grading 0.05 ounce per ton (1.7 grams per metric ton).

In Honduras, Amax's expansion of its El Mochito silver-base metal mine reached 1,500 tons per day. Total expansion is scheduled at 2,500 tons per day by 1985.

Mexico's increasing silver production reached about 56,000,000 ounces (1,750 metric tons) in 1982, and new developments are slated to raise this figure to 64,000,000 ounces (2,000 metric tons) in 1983. The new Real de Angeles mine, which started up in midyear, produced 2,500,000 ounces (78 metric tons) silver in 1982 and will produce 7,000,000 ounces (220 metric tons) this year. Reserves are about 60,000,000 tons of about 2 ounces silver per ton (74 grams per metric ton) plus lead and zinc. Similarly, Industrias Peñoles' output of 14,900,000 ounces (463 metric tons) in 1982 will be increased to 19,500,000 ounces (600 metric tons) in 1983. Lacana Mining's joint venture projects, Preciosa and Temascaltepec, may also be brought into production in 1983-84.

Elsewhere in precious metals, Saudi Arabia signed a management contract with Consolidated Goldfields to bring into production the Mahd ahd Dhahab property, 170 miles (270 kilometers) northeast of Jeddah. Reserves were announced as 1,320,000 tons grading 0.76 ounce gold per ton (26 grams per metric ton), plus silver, zinc, and copper. Scheduled startup is early 1987.

The Arab world's first modern-day gold mine, however, was inaugurated in Morocco in early 1982. The Tiouit mine, near Ouarzazate, has a capacity of 330 tons per day.

In the Far East, new gold fields were reported from Mindoro Island, Philippines, and from several areas in India. At the Pogera property of Mt. Isa Mines-Renison in Papua New Guinea, total reserves were stated as 65,000,000 tons containing 0.10 ounce gold per ton (3.56 grams per metric ton) and 0.42 ounce silver per ton (14.4 grams per metric ton). Consideration is being given to exploitation of a higher grade zone of 12,500,000 tons grading 0.19 ounce gold per ton (6.45 grams per metric ton). At Wolsung, South Korea, a deposit containing 12,000,000 tons with 4.5 ounces silver per ton (155 grams per metric ton) was identified. News of new developments in gold continued to trickle out of China, particularly from Shandong province.

On the African continent, construction proceeded at the Poura gold mine in Upper Volta for startup in 1983 at an annual rate of 64,000 ounces (2,000 kilograms) gold.

SAMPLING 7 foot thick PGM zone with portable core drill at Stillwater igneous complex, Montana, United States.

Platinum Group Metals

Despite the reduced Canadian output due to cutbacks and closures in nickel ore production, of which the platinum group metals are byproducts, world supply again exceeded demand in 1982. Total non-communist mine output of platinum was 1,890,000 ounces (58,800 kilograms) and 884,000 ounces (27,500 kilograms) of palladium, decreases from 1981 of about 24 percent and 29 percent, respectively. (Canadian ores contain more palladium than South African ores. Hence the greater decrease in palladium output resulting from nickel mine closures in Canada.)

South Africa, with 94 percent of 1982 platinum and 85 percent of palladium production, sharply curtailed production so that by year's end the two major producers, Rustenburg Platinum Mines and Impala Platinum Mines, were operating at close to half capacity. Assessment of the Bushveld's UG-2 reef, estimated to contain 800,000,000 ounces (25,000 metric tons) of PGM, continued, particularly near Potgietersrus.

In the United States, discussions were held between Anaconda and Johns-Manville-Chevron regarding joint development of their adjoining deposits in Montana's Stillwater igneous complex. The PGM-bearing horizon, averaging 6 to 7 feet (2 meters) thick, occurs in the banded (or upper) zone of the complex, and has been traced for about 27 miles (43 kilometers). Average grade is about 0.64 ounce per ton (22 grams per metric ton) PGM, with a platinum to palladium ratio of 1 to 3.5. Manville-Chevron would probably control the larger share of the combined PGM resources of the two groups, but Anaconda's property is better located and more accessible.

Uranium

While nuclear power generation in the OECD countries increased by 9 percent in 1982, to reach 14.8 percent of the total generated, uranium production in the non-communist world, estimated at 105,600,000 pounds (48,000,000 kilograms) U_3O_8, declined 8 percent from 1981. With supply still exceeding demand, price dropped drastically to a spot market low of $17 per pound in mid-year, but improved by year's end to the $20 per pound region.

Major production cutbacks occurred in the United States, where output decreased 31 percent to 26,000,000 pounds (12,000 metric tons). Many companies have announced their withdrawal from further uranium exploration and development. Thus, new exploration drilling for uranium was less than half that of the previous year, and only a fraction of the footage drilled three or four years ago.

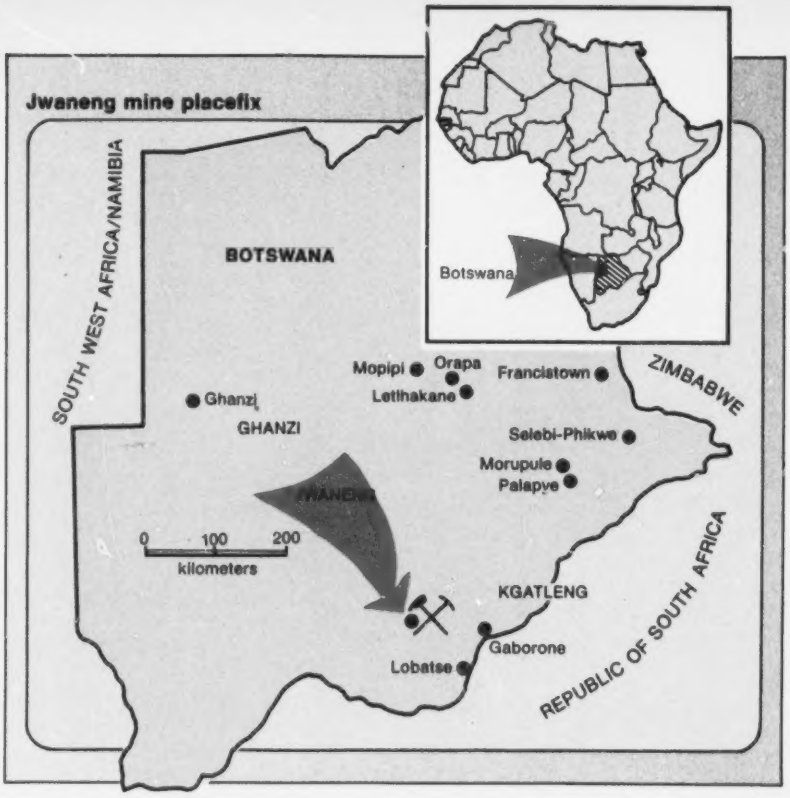
A few discoveries of significant uranium resources were, however, announced. These include Marline Oil's Pittsylvania County, Virginia, United States deposit, where a large resource in fractured gneiss of probable pre-Cambrian age, in close proximity to a triassic paleo-surface, has been outlined. A higher grade portion of about 7,000,000 tons is estimated to grade 0.2 percent U_3O_8. Union Carbide entered into an agreement with Marline to investigate development of the deposit.

The Canadian uranium development activity centered, as in 1981, on northern Saskatchewan. The closing of Eldorado's Beaverlodge operations after 30 years and 67,000,000 pounds (30,000 metric tons) of production, will be more than offset by the opening, in 1983, of the new Key Lake mining complex.

Other developments in and around Saskatchewan's Athabasca Basin include the discovery of a new ore zone, the Jeb, at McClean Lake (Occidental-Inco) grading several percent U_3O_8. A two-year pilot mining project is planned to start in 1984. At Asamera's Dawn Lake property, reserves were increased to over 40,000,000 pounds grading 1.1 percent U_3O_8. Seru Nucleaire found more high-grade mineralization at the Aphebian-Helikian unconformity on its Waterbury Lake property.

Australian uranium production increased significantly, 11,600,000 pounds (5,280 metric tons) versus 7,600,000 pounds (3,500 metric tons) in 1981. Phasing out of a long-time producer, Mary Kathleen, was accompanied by new development. Ranger, with a late-1981 startup, exceeded design capacity and produced 6,900,000 pounds (3,100 metric tons) U_3O_8 in 1982. Pancontinental's Jabiluka, Northern Territory project received the go-ahead, with startup scheduled for 1987. Reserves are near 500,000,000 pounds U_3O_8.

However, two other major Australian uranium mining projects, the Honey-



moon and the Beverley, were blocked by governmental decree. The two deposits contain 42,000,000 pounds of U_3O_8. Also, Exxon withdrew from Western Australia's Yeelirrie development.

Colombia investigated the unusual Berlin discovery, 60 kilometers (36 miles) from La Dorada, in Caldas. The black shale deposit contains about 0.1 percent U_3O_8, with several percent phosphate plus molybdenum and vanadium values. Metallurgical amenability has not been established, but is believed to resemble deposits in Brazil and Sweden.

The government of India plans to develop two new uranium mines in Bihar state at a cost of $100,000,000. Startup in 1990 at 3,000 tons of ore per day will quadruple India's current production.

Worldwide, new exploration projects for uranium were announced by China, Nigeria, Guinea and Ecuador. Most of these are to be carried out with technical and/or financial assistance from international organizations or private companies. In addition, expanded exploration and plans for increased production were announced by Niger and Gabon.

Diamonds

The state of the diamond industry can best be gleaned from the performance of De Beers Consolidated Mines Limited and the marketing organization it controls, the Central Selling Organization (CSO). While total 1982 production from mines in the group increased to 17,400,000 carats (from 15,440,000 in 1981), CSO sales experienced its second successive poor year. Sales decreased 15 percent in dollar terms (but increasing 9 percent in rand terms) over 1981, despite a price increase applicable in the fourth quarter of the year.

The CSO's inventory, therefore, increased significantly, reaching about $2,000,000,000 worth of diamonds. Production capacity stood at 19,000,000 carats per year. De Beers' 1982 earnings declined 32 percent, dropping to about R427,600,000 ($389,100,000) with the operating earnings from diamonds also down some 44 percent to R202,500,000 ($184,200,000).

De Beers became more buyer-conscious, and changed the makeup of its parcelling significantly to meet diamond-cutting industry demands.

The major event for the industry continued to be the development of the Ashton Joint Venture Argyle project in Western Australia. Commercial production from the alluvial field began January 1, 1983, at a projected rate of 5,000,000 carats per year. Production is scheduled to rise to 25,000,000 carats per year by 1985. Exploration of the AK-1 kimberlite pipe, including three shallow sampling shafts and collection of a bulk-sample, continued. To the end of 1982, 63,000 metric tons of kimberlite from AK-1 had yielded a total of 408,400 carats, an average content of 6.5 carats per metric ton. This makes it perhaps the highest grade major kimberlite body ever found (De Beers' highest grade mine at present, Finsch, grades 0.9 carat per metric ton).

Argyle diamonds, however, are mainly of industrial quality. Agreement for the CSO to sell most of Argyle's production received government approval.

In eastern Australia, diamond exploration continued in the Inverellshire area in New South Wales.

In southern Africa, Jwaneng, Botswana's newest diamond project, was inaugurated at a production rate of 3,000,000 carats per year, rising to 4,500,000 carats by 1985. A high proportion of Jwaneng's output is of gem quality. Its full-scale operation will raise Botswana's total diamond production to equal that of South Africa. (For a feature report on Jwaneng, see WORLD MINING, January 1983, page 64.)

Because of the relatively depressed condition of diamond sales, De Beers closed the Letseng-la-Terai mine in Lesotho and the Koffiefontein mine in South Africa, and cutback expansion at the Premier Mine. Production, however, was increased at more profitable operations such as Finsch. Exploration continued in Namibia, on land and offshore. Sampling continued at the kimberlite discovery at Venetia, Transvaal.

Elsewhere in Africa, the World Bank is financing a study for improving the Central African Republic's diamond production, while the International Finance Corporation assisted in financing of the Aredor alluvial diamond-mining project in Guinea. In Sierra Leone, the government announced the go-ahead for Kono kimberlite mine at a capital cost of $118,000,000. Diamonds were reported discovered in the Tortiya area in the Ivory Coast, and the Barsalogo region of Upper Volta. Minière de Bakwanga in Zaire plans to improve production at its Mbuji-Mayi deposits. Zaire, which had withdrawn from De Beers' CSO in 1981, returned to that organization's fold.

Investigation continued into the diamond potential of the Stateline district straddling the Colorado-Wyoming border in the United States. While Cominco's sampling indicated that its deposits were not economic, and some leases were returned to the state of Wyoming, Superior Oil discovered a new pipe, the Evelyn (or Sloan 5), near its Sloan 1 and 2 pipes currently being evaluated. Kimberlite rock was also found by the United States Geological Survey in Michigan's Keweenaw peninsula.

Venezuela's Paragua alluvial diamond field was evaluated by France's BRGM for possible dredge mining. ■

World production of important minerals and metals by 20 leading mining countries in 1977, 1978, 1979, 1980, and 1981

Year	Gold[a]	Silver[a]	Copper[a]	Lead[a]	Zinc[a]	Uranium[a]	Bauxite[a]	Iron Ore[c]	Tin[a]	Molybdenum[a]	Mercury[d]	Nickel[a]	Manganese Ore[a]	Asbestos[a]	Phosphate Rock[c]	Potash[a]	Sulphur[a]	Pyrite[a]
UNITED STATES																		
1978	965,084	39,400,000	1,358,000	529,661	302,669	15,000	1,869,280	80,700,000	110	132,000,482	24,163	13,509	—	93,000	47,256,000	2,268,000	12,521,600	450,000
1979	970,000	31,326,797	1,444,000	551,000	294,693	18,730	1,849,904	85,700,000	110	143,967,000	29,519	15,065	—	93,000	51,611,000	2,464,000	12,846,400	440,000
1980	951,348	31,326,797	1,109,239	604,432	368,848	21,850	1,583,746	69,600,000	110	150,686,000	30,657	14,653	—	80,000	59,840,000	2,239,000	13,259,968	920,000
1981	1,280,000	40,700,000	1,699,500	488,482	345,222	19,140	1,486,000	74,307,000	110	137,303,000	27,933	15,600	—	81,000	58,190,000	2,150,000	12,985,280	880,000
1982	1,226,533	36,516,188	1,256,500	570,082	334,970	13,000	761,435	36,495,000	100	65,948,000	20,760	3,200	70,400	41,223,000	38,000,900	9,503,000	10,100,000	815,000
CANADA																		
1978	1,735,039	40,701,900	723,273	352,000	1,173,700	9,032	—	42,931,000	396	30,674,600	N.A.	140,800	—	1,564,200	—	6,978,400	6,327,000	9,000
1979	1,644,227	36,873,092	700,020	341,820	1,209,918	7,183	—	58,552,688	369	24,584,089	N.A.	139,129	—	1,641,991	—	7,781,827	6,945,558	34,135
1980	1,552,233	33,339,550	779,257	301,216	984,032	7,004	—	49,957,675	290	26,835,600	N.A.	214,442	—	1,468,500	—	8,285,200	8,143,300	35,200
1981	1,746,031	42,433,862	791,326	300,766	1,094,553	8,538	—	53,953,010	273	31,159,611	N.A.	171,048	—	1,268,960	—	7,496,500	9,152,000	12,100
1982	2,203,033	39,753,085	666,822	319,987	1,432,918	9,008	—	37,945,600	169	33,580,246	N.A.	97,619	—	904,200	—	5,715,600	7,818,900	22,000
REPUBLIC OF SOUTH AFRICA																		
1978	24,854,019	3,406,602	226,320	—	143,350	4,984	—	26,626,724	3,176	—	—	N.A.	4,597,995	283,058	20,690,611	—	—	841,643
1979	22,616,656	3,236,347	155,046	—	118,620	6,212	—	27,497,549	2,966	—	—	N.A.	5,700,577	274,106	21,225,950	—	—	350,628
1980	21,669,100	3,116,942	219,867	—	90,000	6,146	—	22,911,987	3,205	—	—	N.A.	6,281,923	295,500	21,489,378	—	—	N.A.
1981	23,139,744	8,303,252	199,424	—	95,500	7,294	—	28,318,856	2,811	—	—	N.A.	5,039,687	235,943	19,483,679	—	—	N.A.
1982	21,324,367	6,951,028	207,580	99,317	100,667	7,549	—	24,062,528	3,338	—	—	N.A.	5,216,517	211,860	N.A.	2,814,666	—	N.A.
AUSTRALIA																		
1978	647,565	26,122,646	244,322	440,320	520,622	187	26,721,762	81,388,218	13,050	—	—	90,594	1,382,979	N.A.	273,160	—	462,193**	N.A.
1979	588,184	26,815,061	258,208	459,233	584,946	256	30,343,500	91,709,000	12,653	—	—	80,655	1,832,600	N.A.	8,312	—	420,483**	N.A.
1980	556,838	24,746,915	238,825	437,668	543,103	568	29,895,800	95,542,000	11,661	—	—	76,835	2,157,100	N.A.	7,283	—	387,083**	N.A.
1981	618,059	25,505,288	245,687	432,424	554,631	568	28,095,100	93,259,100	13,291	—	—	81,409	2,559,800	N.A.	5,430	—	392,116**	N.A.
1982	812,800	28,946,000	271,447	502,391	729,235	N.A.	26,028,200	86,034,200	13,423	—	—	97,408	1,245,422	N.A.	235,000	—	439,259	N.A.
MEXICO																		
1978	201,999	50,777,484	95,905	187,586	269,381	—	—	3,492,455	344	24,000	8,178	24	207,174	—	—	—	1,999,454	—
1979	190,039	49,407,219	117,820	190,801	270,025	—	—	3,968,655	220	105,000	—	22	195,095	—	—	—	2,227,979	—
1980	195,986	47,342,707	175,399	145,549	238,231	—	—	5,087,361	220	130,000	—	20	177,062	—	—	—	2,102,301	
1981	203,155	51,654,829	230,466	157,384	211,629	—	—	5,292,609	70*	994,455	150,000	—	N.A.	208,193	—	—	—	2,077,117
1982	196,244	49,839,605	239,091	145,844	231,310	—	—	5,382,239	N.A.	11,443,950	—	—	183,120	—	—	—	1,815,447	—
CHILE																		
1978	99,998	8,282,000	1,134,912	475	1,994	—	—	7,666,151	—	28,828,800	—	—	25,567	—	—	20,000	10,000	N.A.
1979	104,100	8,625,000	1,167,100	660*	2,200*	—	—	7,451,535	—	29,829,800	—	—	26,400*	—	—	N.A.	N.A.	N.A.
1980	114,800	10,120,000	1,179,400	660*	1,650*	—	—	8,800,000	—	30,124,272	—	—	26,400*	—	—	N.A.	N.A.	N.A.
1981	2[illegible]0	10,200,000	1,080,310	299*	1,097*	—	—	7,648,500	—	33,853,440	—	—	24,000*	—	—	N.A.	N.A.	N.A.
1982	539,338	12,180,091	1,364,770	1,626	6,034	—	—	6,341,874	—	44,103,400	—	—	17,735	—	—	N.A.	N.A.	N.A.
PERU																		
1978	78,000	39,000,000	424,050	187,550	518,000	—	—	4,843,700	—	1,694,000	—	—	—	—	—	—	—	—
1979	141,700	43,415,000	400,387	202,708	622,930	—	—	5,358,158	—	3,931,400	—	—	—	—	—	—	—	—
1980	148,900	39,609,700	363,600	192,912	542,300	—	—	5,600,000	—	4,848,800	—	—	—	—	—	—	—	—
1981	220,000	46,878,000	327,600	205,370	546,370	—	—	4,033,700	—	6,012,512	—	—	—	—	—	—	—	—
1982	175,000*	53,180,000	391,390	193,380	557,810	—	—	5,485,060	—	6,320,600	—	—	—	—	—	—	—	
POLAND																		
1978	—	—	337,700	370,940	244,200	—	—	—	—	—	—	—	—	—	—	—	5,556,100	—
1979	—	—	396,600	92,620	229,900	—	—	—	—	—	—	—	—	—	—	—	5,313,000	—
1980	—	—	392,700	90,200	236,500	—	—	—	—	—	—	—	—	—	—	—	5,703,500	—
1981	—	—	340,000	75,900	183,700	—	—	—	—	—	—	—	—	—	—	—	5,250,300	—
1982	—	—	382,800	86,680	181,940	—	—	—	—	—	—	—	—	—	—	—	5,412,000	—
PHILIPPINES																		
1978	616,702	1,687,240	300,603	1,866	10,263	—	—	1,922	—	121,220	—	34,151	3,912	—	—	—	—	—
1979	530,684	1,804,226	326,740	2,145	10,641	—	—	3,253	—	260,072	—	31,638	5,497	—	—	—	—	—
1980	654,405	1,920,046	305,687	1,782	7,777	—	—	—	—	193,592	—	27,920	—	—	—	—	—	—
1981	758,290	2,023,600	332,563	1,172	5,819	—	—	—	—	207,270	—	23,643	—	—	—	—	—	—
1982 *	834,421	1,984,400	322,065	N.A.	3,302	—	—	5,461	—	176,400	—	12,432	1,711	—	—	—	—	—
JAPAN																		
1978	146,864	9,740,949	80,724	62,553	302,589	—	—	581,900	603	195,360	—	—	118,236	—	—	—	N.A.	1,232,613
1979	132,876	8,665,068	59,960	51,621	267,689	—	—	458,000	726	182,160	—	—	97,173	—	—	—	N.A.	948,584
1980	145,222	8,878,705	58,540	49,241	261,940	—	—	478,000	604	143,880	—	—	87,536	—	—	—	N.A.	802,490
1981	99,300	8,981,700	56,700	51,740	266,800	—	—	478,000	577	260,000	—	—	N.A.	—	—	—	N.A.	N.A.
1982	105,154	9,842,318	56,134	50,470	275,086	—	—	397,100	586	N.A.	—	—	N.A.	—	—	—	N.A.	N.A.

YUGOSLAVIA																		
1978	223,000	5,131,140	165,911	128,373	101,455	—	2,822,600	4,472,720	—	—	928	—	34,914	11,396	—	—	—	470,800
1979	N.A.	5,208,300	151,250	122,144	108,247	—	3,313,200	4,534,356	—	—	—	—	35,552	11,045	—	—	—	N.A.
1980	N.A.	4,790,350	144,417	111,926	92,990	—	3,451,800	4,449,094	—	—	58	—	40,040	13,317	—	—	—	N.A.
1981	560,696	4,871,339	111,700	130,000	106,000	—	3,249,000	N.A.	—	—	174	—	33,400	14,950	—	—	—	N.A.
1982	622,624	3,372,226	139,566	89,373	95,444	—	N.A.	N.A.	—	—	N.A.	—	N.A.	12,822	—	—	—	N.A.
BOLIVIA																		
1978	24,755	6,462,305	3,593	14,758	63,481	—	—	—	33,878	—	—	—	—	—	—	—	N.A.	—
1979	30,300*	5,556,665	1,941	17,029	56,524	—	—	—	30,672	—	—	—	—	—	—	—	N.A.	—
1980	52,074	6,099,337	2,071	18,946	55,286	—	—	—	29,998	—	—	—	—	—	—	—	N.A.	—
1981	66,371	6,601,568	2,900	18,432	51,732	—	—	—	29,780	—	—	—	—	—	—	—	N.A.	—
1982	40,145	6,003,634	2,497	13,676	50,233	—	—	—	29,499	—	—	—	—	—	—	—	N.A.	—
BRAZIL																		
1978	210,000	—	441	—	52,800	—	1,250,000	74,250,000	10,200	—	—	6,600	876,960	110,000	560,000	—	34,000	—
1979	143,389	—	5,780	—	69,843	—	3,172,120	117,502,000	11,691	—	—	3,260	2,145,881	110,000*	581,250	—	35,000*	—
1980	482,178	—	11,000	—	84,700	—	3,300,000	111,800,000	11,702	—	—	2,795	1,353,176	110,000*	930,000	—	35,000*	—
1981	514,488	—	17,960	—	67,120	—	3,569,000	108,800,000	14,000	—	—	2,992	2,100,000*	110,000*	2,800,000	—	35,000*	—
1982	1,446,000	—	73,230	—	121,477	—	4,950,000	121,000,000	9,900	—	—	5,289	1,430,000	130,000	2,800,000	—	35,000*	—
SWEDEN																		
1978	76,300	5,144,000	49,841	83,655	181,500	N.A.	—	21,056,280	—	—	—	—	—	—	—	—	15,000*	532,400
1979	70,000	5,700,000	52,800	79,695	173,316	N.A.	—	26,060,000	—	—	—	—	—	—	—	—	N.A.	492,800
1980	70,000	5,700,000	49,775	67,320	178,398	N.A.	—	26,698,569	—	—	—	—	—	—	—	—	N.A.	435,600
1981	70,000	5,400,000	51,000	81,180	194,722	N.A.	—	25,547,000	—	—	—	—	—	—	—	—	N.A.	463,100
1982	70,000*	5,400,000*	53,768	79,200	201,718	N.A.	—	17,751,800	—	—	—	—	—	—	—	—	N.A.	468,900
ZAIRE																		
1978	80,000*	2,716,000*	463,100*	—	91,850*	—	—	—	2,549*	—	—	—	—	—	—	—	—	—
1979	96,000*	2,850,000*	446,600*	—	80,500*	—	—	—	2,200*	—	—	—	—	—	—	—	—	—
1980	80,375*	2,777,940	495,000*	—	73,000*	—	—	—	2,860	—	—	—	—	—	—	—	—	—
1981	70,000*	2,500,000*	500,000*	—	83,800*	—	—	—	2,500*	—	—	—	—	—	—	—	—	—
1982	62,293	1,753,436	553,164	—	79,836	—	—	—	3,458	—	—	—	—	—	—	—	—	—
ZAMBIA																		
1978	8,326	1,069,341	659,602	13,971	46,742	—	—	—	5	—	—	—	—	—	—	—	1,002	22,000*
1979	7,973	913,606	644,651	14,033	42,034	—	—	4,161	2	—	—	—	—	—	—	—	1,358	N.A.
1980	10,288*	761,955*	670,929	11,000	24,970	—	—	4,550	—	—	—	—	—	—	—	—	1,500	N.A.
1981	11,500*	714,400*	600,000	17,000*	36,799*	—	—	N.A.	—	—	—	—	—	—	—	—	N.A.	N.A.
1982	11,500*	714,400*	622,931*	N.A.	N.A.	—	—	N.A.	—	—	—	—	—	—	—	—	N.A.	N.A.
SOUTH WEST AFRICA[8]																		
1978	—	N.A.	49,500	44,000	24,200	4,400	—	—	842	—	—	—	—	—	—	—	—	N.A.
1979	—	N.A.	42,900	38,500	22,000	5,478	—	—	770	—	—	—	—	—	—	—	—	N.A.
1980	—	N.A.	44,561	55,000	26,401	5,775	—	—	770	—	—	—	—	—	—	—	—	N.A.
1981	—	N.A.	45,000*	55,000*	26,000*	5,775*	—	—	770*	—	—	—	—	—	—	—	—	N.A.
1982	—	N.A.	47,000*	55,000*	26,000*	5,000*	—	—	770*	—	—	—	—	—	—	—	—	N.A.
FRANCE																		
1978	41,795	6,526,450	—	31,195	45,206	2,105	2,175,250	32,784,920	—	—	—	—	—	—	—	1,958,000	2,090,000	—
1979	40,445	7,355,480	—	28,529	39,670	2,596	2,167,000	31,100,160	—	—	—	—	—	—	—	2,113,000	2,135,100	—
1980	35,365	7,652,288	—	28,459	38,766	2,860	2,081,761	29,000,000	—	—	—	—	—	—	—	2,080,177	2,024,000	—
1981	32,205	9,728,000	—	29,275	39,318	2,555	2,081,761	21,800,000	—	—	—	—	—	—	—	1,831,000	2,024,000	—
1982	67609	N.A.	50,820	229,460	278,740	3,163	1,870,000	19,012,000	—	—	—	—	—	—	—	1,871,100	1,795,200	—
NORWAY																		
1978	—	—	31,818	3,604	32,375	—	—	3,586,000	—	—	—	561	—	—	—	—	—	161,315
1979	—	—	31,585	3,296	31,172	—	—	2,614,238	—	—	—	652	—	—	—	—	—	132,304
1980	—	—	37,356	2,985	30,840	—	—	2,447,644	—	—	—	531	—	—	—	—	—	208,285
1981	—	—	351465	3,214	29,696	—	—	2,612,830	—	—	—	4,000	—	—	—	—	—	206,300
1982	—	—	26,840	4,340*	86,570	—	—	2,335,041*	—	—	—	28,160	—	—	—	—	—	218,961*
FINLAND																		
1978	31,928	1,243,443	52,398	1,870	121,822	—	—	1,877,258	—	—	1,145	4,677	—	—	—	—	35,000*	251,900
1979	26,000	1,028,000	46,769*	1,928*	63,880	—	—	773,900*	—	—	1,340*	3,500*	—	—	—	—	N.A.	180,196
1980	41,800	1,000,000	38,551*	1,779*	67,997	—	—	810,000*	—	—	2,155*	4,020*	—	—	—	—	N.A.	182,957
1981	40,000	900,000	42,100*	1,800*	59,100	—	—	810,000*	—	—	2,155*	4,020*	—	—	—	—	N.A.	268,882
1982	35,412	1,191,141	40,757	1,600*	60,430	—	—	810,000*	—	—	2,263	7,000	—	—	—	—	N.A.	292,170

1. Preliminary. 2. Ounces. 3. Short tons. 4. Long tons. 5. Pounds. 6. Flasks. 7. Exports. 8. No official statistics released for South West African mineral production. The figures given here are compiled by WORLD MINING editors from a variety of individual sources. *Estimated. **Includes Sulphur content of pyrite. N.A. Not available.

ALGERIA

Société Nationale de Recherches et d'Exploitation Minières' (Sonarem) planned production levels for 1985, announced last year, include; 5,000,000 metric tons of iron ore, 38,000 tons of zinc ore, 19,000 tons of lead ore, 4,200 tons of copper ore, 155,000 tons of barite, 80,000 tons of bentonite, 70,000 tons of kaolin, and 800,000 tons of salt. Significant expansions will be required to achieve these levels as 1980 production was; 3,454,000 tons of iron ore, 15,432 tons of zinc ore, 3,045 tons of lead ore, 768 tons of copper ore, 98,000 tons of barite, 33,680 tons of bentonite, 8,250 tons of kaolin, and 138,000 tons of salt.

Last year, Sonarem also announced that it would immediately increase iron ore production by 17 percent to 4,200,000 tons to supply the El Hadjar steelworks. In 1981 production rose by just 5 percent to 3,600,000 tons. Other increases planned for 1982 were a 28 percent increase in phosphate production to 1,200,000 tons and a 37 percent increase in basalt production to 202,000 tons.

Sonarem called for tenders for a technical and economic feasibility study of the Tiririne gold deposit in the Hoggar region. Reserves are thought to amount to 20 tons of contained gold. A mine producing 1,000 kilograms (32,150 ounces) of gold a year could be operating by 1986. Sofremines, in cooperation with Sonarem, is studying the copper and copper-lead-zinc deposits of Bousoufa and Oued el Kebir.

ANGOLA

The mining of minerals now comes under a number of separate government controlled agencies set up under the ministry of industry under the direct control of the National Directorate of Geology and Mining. These bodies include; Empresa Nacional de Diamantes de Angola (Endiama) for diamonds, Empresa Nacional de Ferro (Ferrangol) for iron ore and manganese, Fosfang for phosphate, Minaquartzo for quartz, and Roremina for ornamental stones.

Endiama was established in 1981 for the exploration, study, mining, processing, and marketing of diamonds. It was set up from the state's share-holding in Diamang (over 77 percent). The production targets set for 1982 and 1983 were 1,800,000 and 2,000,000 carats respectively. In fact, 1981 production, at 1,400,000 carats, was 13 percent below target and even fell below 1980 production. Therefore it seems unlikely that the 1982 target was achieved. One of the major problems is illegal diamond mining and smuggling.

Major developments have been occuring in the iron ore sector. Ferrangol, also set up in 1981, in cooperation with Austromineral is reactivating the Kassinga iron ore mines in the south. The first shipment of ore, 150,000 metric tons, was made at the end of 1981, although the ministry of industry shows no target for 1982. A sustained annual production of more than 1,000,000 tons a year is planned by 1985. Initial mining is from Kassinga Norte, with reserves of 21,700,000 tons. Kassinga Sul, with reserves of 21,500,000 tons will not be mined for some time.

Ferroangol has two other concessions, one in the north, and one in the south, near the rivers Kwanza (Kassala-Kitungo) and Cuenene/Kubango (Jamba and Tchamutete) respectively. The Kassala-Kitungo ore bodies contain more than 300,000,000 tons at about 33 percent Fe. Kassala's reserves are about 72,000,000 tons of which some 43,000,000 tons could be mined by open pit. At Kitungo, proven reserves are estimated at about 177,000,000 tons of which only some 40,000,000 tons are suitable for open pit.

Kassala will be mined first and Kitungo will be phased in later as the former's reserves become depleted. Upgraded product will be carried by a pipeline to the pellet plant at Luanda.

Empresa Miniera dos Fosfatos do Zaire (Fosfang) may sound as though it belongs to another country but it was set up in mid 1979 to start exploration of large phosphate deposits in the north in the provinces of Zaire, at Kindonacaxa, and Cabinda, at Mongo-Tando.

A pilot plant to produce 15,000 tons of crushed phosphate was built at Kindonacaxa in 1981. The first production target to appear in the ministry of industry's plans is 10,000 tons in 1982. Metallurgical testing suggests that these deposits are suitable for producing simple super-phosphates.

In Cabinda Energ-Project of Yugoslavia is prospecting for phosphate over an area of 10 square kilometers (3.9 square miles). The work began in May last year at Cacongo, in the Mongo-Tando area, and by October results indicated good quality phosphate. In addition, a sedimentary deposit of phosphatic rock has been discovered at Loango Pequeno, near Mongo-Tando, where the mineral is on surface.

Geological mapping is to be carried out over selected areas on successively larger scales, depending on the economic interest of each area. It is planned that comprehensive mapping of the whole country be completed by the end of 1985. There is much potential for further investigations.

In the west there are possibilities of stratiform deposits of copper, phosphorites, sulphur, asphalts, and construction materials. In the southern and central parts there are known deposits of iron ore and manganese and in the east, largely unexplored, there are indications of coal and bauxite deposits. In various parts of the country there have been discoveries and some work carried out on copper, wolfram, tin, and gold prospects.

BENIN

Pilot mining of the Perma gold prospect has been started by the Office Beninois des Mines (Obemines). The deposits were last mined between 1939 and 1955. They were studied by Bureau de Recherches Géologique et Minières (BRGM) between 1960 and 1965.

Other medium-term programs for mineral development will focus on phosphates; kaolin; marble, through a joint venture company formed with Libya (Belimine) to develop deposits in Zou province; and iron ore.

The country's mineral resources remain largely unexplored but it is hoped that in the near future geological mapping will be completed and exploration programs at clearly identified targets will allow a more systematic program for developing anú upgrading the country's mineral potential. A more complete review of known mineral resources appeared in WORLD MINING, August 1982, page 111.

BOTSWANA

During the year 1982, new all time records were established for production of coal, copper and diamonds.

The most outstanding event of the year, was the opening of the Jwaneng diamond mine (World Mining, January 1983, pages 64 to 68). Production from this mine combined with the existing Debswana mines will insure Botswana's position among the worlds leading diamond producers. Also of great importance was the signing of a joint venture agreement to undertake a feasibility study that could lead to the development

Botswana production of minerals in metric tons

Commodity	1980	1981	1982
Coal	371,395	380,898	414,778
Cu-Ni matte	40,099	46,565	45,685
Contained Cu	15,553	17,819	18,375
Contained Ni	15,442	18,278	17,756
Diamonds[1]	5,161	4,960	7,768

1. Carats. 1.0 metric ton = 1.0 short tons. 1.0 short ton = 0.907 metric ton.

of a large scale mine that would produce thermal coal for export.

Despite record metal production in 1982, BCL Ltd. continues to experience serious financial difficulty due to the very low prices received for its metals. A third restructuring of its major debt was accomplished at mid-year and subsequent arrangments completed to assure continued production until at least the end of 1983. Most of the Cu-Ni matte continued to be sent to the AMAX refinery in Port Nickel with a minor amount of low sulphur granulated matte goint to Rio Tinto Mining (Zimbabwe) Ltd.

The production of the major new Jwaneng mine, plus continued high production from the Orapa and Letlhakane mines increased output to 7,768,000 carats compared to 4,960,000 carats in 1981. This will be increased to nearly 9,000,000 carats in 1983. New diamond sorting and evaluation facilities were established for all of Botswana's production and a small diamond polishing enterprise was also started.

The Sua Pan soda ash deposits, which have received periodic attention, were once again the subject of much interest and it is expected that this enormous resource will finally be fully evaluated.

There was further assessment of the copper deposits at Bushman and Matsitama and in the south of the country drilling commenced over a layered mafic intrusive complex which is being investigated for Bushveldt type platinum group and chromium metals mineralization.

Prospecting for base metals took place on the Aha Hills in the far west and in the Francistown region. Interest has also been maintained in the evaluation of small gold deposits in the northeast, including gold rich tailings dumps. The year also saw a substantial investigation of geophysically indicated features beneath the Kalahari.

Botswana's only coal mine, the Morupule Colliery, completed an expansion program and achieved an annual rated capacity of 480,000 tons. This mine supplies almost all the domestic coal requirements. Further expansion is planned to supply the increasing electrical power requirements of the country.

Despite the depressed conditions in mining there continued to be active exploration programs throughout the country. Whereas in 1980 only one company was evaluating concessions in the eastern coalfields, by 1982 five major companies were prospecting for coal. Vigorous activity was also maintained in diamond exploration across large areas in central, southern and eastern Botswana.

BURUNDI

Investigation of the nickel laterites in the Musongato area continued during 1982. Reserves have been estimated at 73,000,000 metric tons of ore containing 1.6 percent Ni, 0.3 percent Cu, and 0.1 percent Co. Immediately surrounding the main target area are further reserves thought to amount to an additional 300,000,000 tons. Consultants for the exploration project are Exploration and Bergbau. In 1982 tenders were invited for a major exploration program to be carried out on the prospect, this contract went to Foraky.

Pilot plant tests have already been carried out with, reportedly, successfull recovery of nickel, copper, and cobalt. Any metallurgical process used would require substantial amounts of steam. Burundi has substantial peat deposits which are being examined as a potential source of power. Probable reserves of the country have been estimated at some 500,000,000 tons and proven reserves in Akanyaru district, to the north near the border with Rwanda, are 35,000,000 tons, when dried to 30 percent moisture.

During 1982, work also continued on the Matongo phosphate prospect. During the first half of 1982, Drill Sure was engaged as drilling consultants and undertook an investigation of drilling aspects. Drill Sure subsequently provided a drilling supervisor and drillers for the project, being supervised by the British Sulphur Corporation for the Department of Geology and Mines under United Nations/World Bank auspices. Techniques were developed to increase drilling production while achieving high core recovery in broken and difficult conditions. Mud/polymer systems were engineered and cementing used to overcome in-hole water and sand problems.

CAMEROON

More information was gathered last year on the bauxite deposits of the Adamaoua area. The deposits, distributed around Fongo-Tongo, Dschang, Foumban, and Bangam, is now reported to contain indicated reserves of about 1,400,000,000 metric tons, with another 60,000,000 tons of inferred reserves. The grade is 43 percent alumina and 3.4 percent SiO_2. Société d'Etudes des Bauxites du Cameroun (Sebacam) has already considered the possibility of an operation producing 15,000,000 tons a year, which would require an investment of more than $1,000,000,000. A more modest, intermediate project at an output of 1,000,000 to 2,000,000 tons is now being examined.

Alucam, a joint venture between the government and Pechiney, already operates an 80,000-ton-a-year smelter at Edéa. A second plant is being planned for Victoria.

Good progress was made in the study of the Mamelles iron ore deposit near Kribi on the coast south of Douala. The structure of the deposit has been defined and the reserves estimated. The reserve estimation has not been made available but earlier work had indicated some 200,000,000 tons at an average grade of 30 percent Fe, with no impurities. The project is managed by Société d'Etudes de Fer du Cameroun (Sefercam). This company is a joint venture between the state, Serem, Gfm Partners, and Krupp.

Evidence of potential rutile reserves were discovered by Bureau de Recherches Géologique et Minières (BRGM) as part of its exploration program in the southwest of the country. BRGM is also prospecting for tungsten and uranium in the country.

EGYPT

Negotiations between Egypt and the United States acting through the Agency for International Development (AID) are underway in order to reach a grant agreement to identify and asses the mineral and petroleum resources of Egypt as a means of attracting additional domestic and foreign investment.

This will include the following work in the mining sector: regional geological mapping; exploration and evaluation of some mineral deposits; establishment of three mining companies; modernization of the chemical and mineralogical laboratories; and training of Egyptian personnel in the United States

The construction of a new concentrator on the Red Sea coast to treat ore from cassiterite placer deposits is proceeding. It is planned to start production in 1984.

Major efforts have been made to evaluate new resources of building materials (clays, sands and limestones) and raw materials for the cement industry.

Negotiations with the United States for sulphur exploration on the Red Sea coast are still underway.

Egyptian mineral production in metric tons

Commodity	1980	1981	1982
Iron ore	1,860,700	1,943,500	2,036,856
Phosphate	702,500	736,800	719,882
Barite	8,800	2,100	4,320
Bentonite	5,200	3,700	4,032
Clays	810,000	995,000	1,027,092
Feldspar	4,400	3,500	8,294
Fluorspar	770	550	750
Kaolin	48,000	32,200	32,410
Limestone	6,200,000	5,534,800	8,884,920
Quartz	9,900	12,830	10,662
Talc	5,400	5,800	7,080
Asbestos and vermiculite	1,600	1,040	1,600
Marble[1]	33,000	46,900	31,184

1. Cubic meters. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric ton.

Intensive studies have been carried out in cooperation with a British firm to reopen the Maghara coal mine in central Sinai. The feasibility study was expected to be ready in March 1983.

EQUATORIAL GUINEA

This country has never had a commercial mining industry but, as reported last year, is keen to stimulate interest in exploration and its mineral potential in general. This incentive took the form of new mining laws to attract foreign companies to participate in exploration, development, and mining. Recent Spanish exploration work revealed some gold-silver prospects in Rio Muni.

Last year Bureau de Recherches Géologique et Minières (BRGM) completed its second campaign in the program to put together a mineral inventory of the country. A number of interesting mineral showings have been revealed.

GABON

In 1981, manganese production by Compagnie Minière de l'Ogooué (Comilog) fell drastically by 30 percent to 1,481,538 metric tons. Figures for 1982 have not been made available yet but it is know that Comilog was hoping to bring the production level back up to more than 1,500,000 tons and to maintain a reasonable price level in Francs, against fluctuations in the dollar rate. The realisation of plans to increase production significantly and to build a ferromanganese plant are dependent on the completion of the Transgabon railroad to Moanda. Reserves are estimated at 200,000,000 tons of ore.

Despite the weak world uranium market, Compagnie des Mines d'Uranium de Franceville (Comuf) intends to maintain production at a level of at least 1,000 metric tons of contained metal. Total reserves are estimated at 35,000 tons, 25,000 tons of which are in the three deposits currently being mined at Mounana, Oklo, and Boyindzi.

In the northeast of the country, at Bélinga, proven reserves of iron ore amount to 300,000,000 tons. It is a high grade ore, containing 67 percent Fe, and at least half the reserves contains no phosphorus. Including inferred reserves, the total resource is estimated to be in excess of 800,000,000 tons. Production could start in 1986, however this depends on the completion of the Transgabon railroad to Mekambo, 250 kilometers (155 miles) from Booué and an improvement in the world iron and steel markets. At the moment more than $16,000,000 have been invested by Société des Mines de Fer de Mekambo (Somifer). However, a total investment of some $55,000,000 is expected to be required to develop the deposits. A syndicate involving Bureau de Recherches Géologique et Minières (BRGM), Comuf, and the state has also discovered some interesting iron ore prospects in the Etéké region.

The Kroussou syndicate continued exploration of barite prospects. A reserve of 1,000,000 tons has been identified on the Nyanga river between Mayumba and Tchibanga. Other prospects have been discovered in the Kroussou region. Commercial mining is expected to start in 1985 or 1986. Studies of the feasibility of mining barite at Dourekiki, by a BRGM-Comilog joint venture, continue.

Core drilling was carried out last year by the Etéké consortium (BRGM and Comuf) of gold mineralized zones at Ovala and Ndombo-Mobi, in the Etéké-Ovala region. Many high grade talc deposits have been identified, notably the one at Doussala.

GHANA

It appears that a number of planned developments in the gold mining industry have been frustrated by equipment shortages. Therefore, the Consolidated Gold Fields review, Gold 1983, has revised its figures down for the past two years. Gold 1983 estimates Ghana's production for 1982 at 12,000 kilograms

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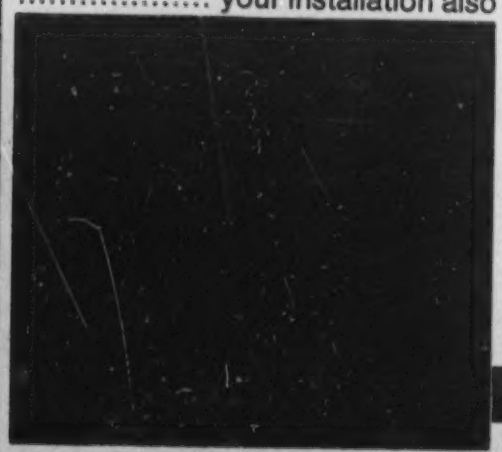

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Ghanaian production of minerals in metric tons

Commodity	1980[3]	1981[3]	1982[4]
Gold[1]	437,669	349,870	385,800
Diamonds[2]	1,469,914	1,048,908	1,200,000
Bauxite	313,768	176,155	200,000
Manganese	368,593	280,409	300,000

1. ounces. 2. carats. 3. Source: The Ghana Chamber of Mines. N.B. The Chamber of Mines financial year was changed in 1980. Thus, the 1980 year runs from April 1979 to June 1980 (15 months) and the 1981 year runs from July 1980 to June 1981. 4. World Mining estimates. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.0907 metric ton.

(385,800 ounces) compared with 11,600 kilograms (372,940 ounces) in the calendar year of 1981. Output from the major Ashanti mine is reported to have increased again during 1982. Mine production should continue to grow slowly in Ghana in the future.

The State Gold Mining Corporation plans to sink two new shafts at the Prestea and Tarkwa mines. Capital required for the project has been estimated at $250,000,000. The shafts are essential to restore productivity to former levels. Production has been as high as 373 kilograms (12,000 ounces) of gold per month, but by March 1982 had slumped to just 101 kilograms (3,240 ounces).

Production started at the maganese nodulizing plant installed by the Ghana National Manganese Corporation at Nsuta in the western region. The plant has a capacity of 1,100 to 1,500 metric tons per day. Some $27,000,000 has been spent on rehabilitating the manganese mine, first developed in 1936. The mine is now expected to continue to produce low and high grade manganese ore for at least another 20 years.

It was estimated last year that Ghana Bauxite Company Ltd. was losing $18.00 on every ton of bauxite it produced. One of the problems has been the decline in production, which has fallen from 300,000 tons in the early 1970's to a target of 200,000 tons for 1982. A major reason for this is that only six or seven of the 12 trains needed each week actually run, causing significant delays on the Awaso to Takoradi railroad. Naturally, depressed world markets have kept production below its full potential of 400,000 tons. However, some $40,000,000 are needed for improvements by the railway corporation before any improved output can be achieved.

In the light of the country's bauxite problems Kibi Bauxite Development Company's plans look less likely to come to fruition on schedule, although there have been no further reports since last year. The company is planning a 2,500,000-ton-per-year bauxite mine and an 800,000-ton alumina refinery. When first announced, the project was scheduled for completion in 1985. Reserves of the Kibi deposit, 75 kilometers (47 miles) north of Accra, are estimated to be 150,000,000 tons.

There is a 200,000-ton-a-year aluminum smelter at Tema, operated by Volta Aluminium Company (Valco), which imports alumina from Jamaica. Valco is a joint venture between Kaiser Aluminum and Reynolds Metals. Government last year indicated that it plans to seek a revision of its agreement with Valco, particularly the section governing power charges. Discussions are underway but government has to be sure not to make any increases so high that Valco shuts down its operation.

GUINEA

Bauxite remains this country's single most important mineral product. There are three mines in operation. Boké, operated by Compagnie des Bauxites de Guinée (Cbg), was targetted for a production of 10,000,000 metric tons bauxite last year; Kindia, mined by l'Office des Bauxites de Kindia (Obk), produces some 3,000,000 tons bauxite per year; and the Fria mine and plant produces some 650,000 tons of alumina per year. Two other deposits are being developed; Gaoual-Aye Koye, with reserves of 1,300,000,000 tons containing 58 to 62 percent Al_2O_3; and Dabola, containing 1,000,000,000 tons at 48 to 52 percent Al_2O_3. A further 4,000,000,000-ton reserve in the northern region of Tougué is also being studied.

Development of Societé Mixte Aredor-Guinea's diamond mining project is well underway. Production is expected to start in the first quarter of 1984. The recovery plant, built by Klockner Industrie-Anlagen for which site construction began in February 1983, is designed to treat 400,000 cubic meters (523,000 cubic yards) per year. The expected recovery is 0.5 carats per cubic meter. The project is a joint venture between the state and Bridge Oil. The 25-year exploration permit that Bridge Oil entered into with government covers 23,000 square kilometers (8,880 square miles), which is to be reduced to 1,500 square kilometers (580 square miles) at the start of production. To date only 50 square kilometers (19 square miles) have been prospected and a reserve of 1,400,000 carats has been proven.

The diamond bearing gravel extends to an average depth of 7 meters (23 feet). Prospecting continues with a view to proving a reserve of 2,000,000 carats. In excess of 90 percent of the proven reserves are of gem quality.

Several large kimberlite pipes exist in the area but prospecting in these has only recently begun, together with investigation of gold in the gravel. Evidence of gold in the gravel has been established and the significance of the find is currently being evaluated.

Other companies are involved in joint venture diamond exploration programs. The Industrial Diamond Company has a permit covering 30,000 square kilometers (11,580 square miles) and Charles Anthony Diamonds' permit covers 20,000 square kilometers (7,720 square miles).

Some of the world's highest quality iron ore is to be found in the mountains along the border with Liberia. For the past 10 years Guinea has been studying the feasibility of mining two deposits, at Nimba and Simandou. At Mount Nimba reserves include some 315,000,000 tons of ore containing 66.5 percent Fe. Total reserves have been evaluated by Kaiser Engineers at 800,000,000 tons. Société des Mines de Fer de Guinée pour l'Exploitation des Monts Nimba (Mifergui-Nimba is now confident that it can arrange financing (of some $1,000,000,000) for the development of mining with a production start-up in 1990.

Société Minière International du Quebec Inc. (Somiq) is developing an open pit gold mine in the northeast of the country. Somiq estimates an overall grade of 5 grams (0.16 ounce) per ton. A plant processing 1,000 tons per day went into operation in early 1982.

GUINEA-BISSAU

Portugal is providing assistance in a prospecting program in the east of the country. It seems likely that the joint venture will explore for all minerals except phosphate and bauxite. Agreements already exist with Belgium and France for phosphate exploration, and the Soviet Union is interested in carrying out bauxite exploration.

In its phosphate exploration program Bureau de Recherches Géologique et Minières (BRGM) has achieved interesting results in the Farim area where phosphate beds, partially explored, are likely to show good reserve potential.

IVORY COAST

As in the previous year mining sector activity in Ivory Coast was characterized by prospecting. The main targets were sulphide and gold deposits, and uranium. The outstanding feature of the campaign was Sodemi's discovery of a sulphide copper-nickel deposit at Samapleu-Gbangbapleu close to Voroudougou in the Bianbouma region.

Sodemi continued gold prospecting in the Seguela region in the Mount Goma volcano sediments. Some 220 samples averaging 2.5 meters deep were taken from the stream beds of the main tributaries of the Tenou. Most samples contained gold and scheelite. The samples taken from the western slopes of Mount Goma were generally higher in gold and scheelite than those from the eastern slope. Several placers were identified in the Tenou flats.

Sodemi also prospected for gold in the Aboisso region in a joint venture with

a syndicate of three private Canadian companies. The work was mainly geochemical and mineralogical sampling and high gold grades of 1 to 2 grams per cubic meter were found in some pits.

The French Bureau de Recherches Géologiques et Minières assisted in the prospecting of Toulepleu and worked on its own permit areas at Bondoukou and Fetekro. At Toulepleu gold bearing disseminated sulphide deposits were prospected. At Bondoulou the targets were gold bearing polymetallics, prospects indicated by the geological and structural context. At Fetekro concentrations of disseminated sulphides with gold were sought in connection with fracture zones.

Work included pitting and trenching to take vein samples, geological surveying with VLF-Resistance-Mag-Maxmin measurements and self and induced polarization, mobile augur drilling along structures, and sampling of alluvials and gossans. No important results are reported but some of the Toulepleu anomalies will be further investigated.

Comici's gold prospecting program which has been underway since last year in the Tabou region has shown up superficial mineralization over an area of almost 2 square kilometers. Washing of the alluvial gravels has not yielded nuggets but in general the grades are encouraging. Pit samples have an average range from 0.8 to 2.4 grams per cubic meter, exceptionally 11.1 grams per cubic meter. Prospecting continues in the areas not yet covered to get an idea of the total reserves.

Sodemi continued uranium prospecting in the Odienne region and completed more than 1,000 kilometers of carborne spectrometric surveys. About 50 anomalies, six of them uranium bearing, are programd for further investigation. Six radio anomalies discovered from the air were checked on the ground and two were found to be uranium bearing, the others being essentially thorium. Two other groups of uranium anomalies (Linguesso-Dyafana-Tindrima and Dyafana-Goulia) were prospected in detail with very encouraging results.

Sodemi cored 1,610 meters of BQ hole at Kanta on pyrrhotite, magnetite, and ilmenite mineralization. At Samapleu-Gbangapleu it drilled 15 holes coring 2,728 meters of BQ to discover a copper-nickel sulphide deposit in a basic-ultrabasic complex. THis is the first time that such a deposit has been discovered in the Ivory Coast.

The feasibility study of the Ity gold project which was presented in 1981 was revised in June 1982. It is now based on an annual production of 160,000 tons of ore grading 8.4 grams (O.27 ounce) per ton for 13 years. Total investment is estimated at 13,000,000,000 Central African Francs ($35,000,000). The future operating company, formed by Sodemi and BRGM, the Société Des Mines d'Ity should be registered during 1983.

KENYA

The country's financial problems continued in 1982 with a further deterioration in the foreign exchange reserves. The IMF assisted with loans in the latter part of the year. A further devaluation of the currency by 15 percent along with the reintroduction of the government export subsidy took place in December in efforts to stimulate the export sector. An attempted coup against the government of President Moi seriously undermined the confidence of local and overseas investors. While no significant new mining developments took place in 1982, the in-

Kenyan mineral production in metric tons

Commodity	1981	1982
Cement	1,379,985	1,449,360
Soda ash	157,870	160,440
Salt	25,801	24,411
Fluorspar	96,025	89,361
Limestone products	35,767	40,430
Diatomite	1,810	1,790
Kaolin	2,870	1,920
Gypsum	280	480
Wollastonite	950	1,100

1.0 short ton = 0.907 metric ton 1.0 metric ton = 1.10 short tons.

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dustry as a whole continued to strengthen.

The poor market for fluorspar and a two-week maintenance shutdown in 1982 adversely affected production and sales of acid grade fluorspar by the Kenya Fluorspar Co, resulting in a 2,500-metric-ton shortfall in production.

The Magadi Soda Co. was affected by the world recession as the soda ash market became increasingly depressed. The company is however confident of the future and has embarked on an expansion program to raise production to 300,000 tons of soda ash per year and to upgrade the materials handling facilities.

Most of the smaller mineral producers, producing mainly for the local market continued to perform well during 1982. Athi River Mining Ltd. has recently stepped up production of gypsum and plans to produce 8,000 tons in 1983. The company's recent discovery of a barite deposit capable of yielding 11,000 tons per year looks very promising. Both the gypsum and barite are intended for export.

Bamburi Portland Cement Co. produced a record 1,150,000 tons of cement products and plans to produce 1,250,000 tons in 1983 and to export 1,000,000 tons of cement products valued at $1,860,000. The increase in production is due to uprating of existing plant. Kenya's other cement company, East African Portland Cement, continued to improve production performance over previous years.

The Mines & Geological Department and organizations from overseas donor countries continued to work on mineral exploration and development programs established over the last few years.

The Samburu-Marsabit geological mapping and exploration project which started in 1981 with funds and technical assistance from the United Kingdom continued with the first part of the project now almost complete. The aim of the project is to produce geological maps of an area of 100,000 square kilometers (38,600 square miles), produce a preliminary inventory of mineral occurrences, and assess water resources.

The Finnish government assisted the Department in a joint venture to survey for industrial minerals. Emphasis has been placed on cement raw materials; ceramic raw materials, such as kaolin; wollastonite, and fertilizer raw materials. So far several areas in western Kenya, namely Koru, Songhor, and West Pokot have been explored. The investigations in these areas were mainly to reassess known limestone prospects to verify reserves and grades.

The Department also continued a ground follow-up program on data provided by an airborne geophysical survey of western Kenya in 1977. The work has involved investigations of air survey anomalies, focussing on kimberlitic and base metal mineralization.

A report by the United Nations Development Program (UNDP) on geological exploration in western Kenya has been completed but details have not been released. An airborne survey of the Kerio Valley carried out by Geosurvey Ltd. now requires ground follow-up.

LESOTHO

In May 1982, the country's only mining operation, De Beers Lesotho Mining Company (Pty) Ltd., closed down. All diamond mining operations ceased at that time. However, the treatment plant continued to treat all available ore from the surface of the satellite pipe together with some stockpiled material until the end of October. During the ten-month period a total of 1,430,000 tons was treated yielding 42,119 carats at an average grade of 2.95 carats per 100 tons. Final clean-up operations were completed by the end of January 1983.

LIBERIA

The heavy reliance on iron ore continues to cause problems for the mining industry. The Liberian American Swedish Minerals Company (Lamco) produced 10,000,000 metric tons of ore in 1982 but expects to reduce output to just 6,500,000 tons this year. The company hopes to maintain a level of 8,000,000 tons a year from 1984 to 1987 but by then the Nimba/Gbahm mines will be exhausted.

Lamco wants to continue mining in Liberia and could move its operations to the Nimba western area. This it could do on its own or in conjunction with Bong Mining Co, which operates in the Bong mountains, about 100 kilometers (62 miles) southwest of Nimba. However, the current state of the market may mean that Lamco has to cease operations totally. Development of Nimba western area has been estimated at a cost of $400,000,000 but this may be reduced to $300,000,000 if agreement can be reached to use Bong's beneficiation facilities. This would mean the construction of a 100-kilometer railroad linking the two mines. Some of the product would be exported via the existing railroad from Bong to Monrovia, the rest could go directly from Nimba to Buchanan.

Lamco hopes to return to profitability next year after making heavy losses since 1978. The cost reduction excerises implemented have reduced the workforce by one third since the fall of 1982.

A project to expand the Mano River iron ore mine of the National Iron Ore Co. Ltd. is underway. At completion, production will be 3,250,000 tons annually, an increase of 30 percent over present capacity. The total cost for the project is expected to be some $67,000,000. Last year a management contract was agreed with Met Chem Consultants of Canada. The confirmed life of the mine after this modernization will be 12 years. Part of the modernization program includes a $3,700,000 contract awarded to Lemminkäinen of Finland for a 4,000-ton surge bin system and associated conveyors and transfer equipment. Work on this started in October and is due for completion at the end of 1983.

MALAWI

A preliminary feasibility study by Lonrho was reported to indicate that mining of the strontianite/monazite deposit in the Kangankhunde carbonatite would be marginally economic. No further pilot work appears to have been carried out at the prospect during the year. The company, however, showed increasing interest in the low-MgO marble deposits at Golomoti, for the manufacture of lime for its sugar factories. An application for an exclusive prospecting licence by the company was under consideration by government at the end of the year.

BPB (Malawi) Ltd., a subsidiary of British Gypsum Ltd. exported a trial consignment of lump kyanite to the United Kingdom, from Kapiridimba. It is also continuing with pre-commercial production of vermiculite from the large deposits outlined at Kapirikamodzi, in Mwanza District.

Union Carbide Corporation submitted to Government the results exploration carried out in 1981 under three reconnaissance licenses. Investigation of the Lower Palaeozoic, Lake Malawi granites produced the first record of tungsten in the country together with significant tin anomalies. Colobium-uranium mineralization at Ilomba hill was confirmed with grab samples averaging over 3 percent Cb_2O_5; a drilling program was recommended. A search for high-grade uranium at the base of the Mafingi Group was unsuccessful. Interest in the known, low grade, uranium deposits was, however, renewed by another company towards the end of the year.

MALI

In 1982 a cooperation protocol was signed between the Soviet Union and the government for gold mining at at Kalana, 190 kilometers (118 miles) south of Bamako, where there is already an operating mine. The Soviet Union is to provide some $16,000,000 towards a total investment of about $22,000,000 needed for an expansion program.

In 1981 the Kalana gold mine, operated by Société Nationale de Recherches et d'Exploitation des Resources

Minières (Sonarem), was producing at a rate of about 400 kilograms (12,860 ounces) of gold annually. Sonarem wishes to to increase production steadily from 480 kilograms (15,432 ounces) to 1,790 kilograms (57,548 ounces) of gold per year, with an additional 473 kilograms (15,207 ounces) of silver. Reserves contain 30,000 kilograms (964,500 ounces) of gold and the life of the mine is expected to be 15 years.

In a joint venture exploration program with the government, Bureau de Recherches Géologique et Minières (BRGM) has discovered various anomalies and vein structures which merit attention as serious targets for future work in the Kéniéba area. In the Kangaba area, where general prospecting continues, some interesting anomalies have been uncovered in the Banankoro zone. The exploration is primarily directed at gold mineralization. BRGM is also continuing with its diamond exploration in the country.

MAURITANIA

Production at the K|dia d'Idjil iron ore mine at Zov|rate, started in 1961, was continued by the Société Nationale Industrielle et Minière de Mauritanie (SNIM). SNIM is a 71 percent state-owned company, the rest being divided between several national and foreign investors. Some 126,000,000 tons of high grade ore (plus-60 percent Fe) and 53,000,000 tons of siliceous ore (50 to 60 percent Fe) has been produced from five principle deposits (Tazadit, Rovessa, F'dérick, Seyala, and Azouzils) geographically grouped in the three distinct areas of (Tazadit, Rouessa, F'dérick). Each with its own crushing-screening plant.

Iron ore production in 1982 was 8,527,000 tons, compared to 8,430,000 tons in 1981, and 8,936,000 tons in 1980. Of this 7,654,000 tons was exported in 1982, compared to 8,881,000 tons in 1981, and 8,725,000 tons in 1980.

If production continues at its present level all existing deposits of the Kédia will be totally exhausted by 1992.

The Guelb el Rhein project will compensate for gradual depletion of the Kédia deposits and will ensure an increased annual production of 9,000,000 to 12,000,000 tons. It will have 6,000,000 tons of annual capacity from 1985 onwards. The Oum Anwaguen project, at 6,000,000 tons per year, is to commence in 1982.

The Guelb el Rhein reserves are estimated at 350,000,000 tons of magnetite ore of average grade 38 percent. Production is planned to start in 1985 at 2,500,000 tons per year rising to 6,000,000 tons later.

The Kédia deposits are connected by a 650-kilometer railroad to the Nouadhibou port where additional crushing screening and blending is performed to commercial specifications for ore shipping.

Joint studies by SNIM and BRGM (France) on the Bofal phosphate outcrops have disclosed estimated reserves of the order of 100,000,000 tons of coprolite ore at 20 to 22 percent P_2O_5 with a stripping ratio varying between 5 and 8 to 1. A prefeasibility study is currently being carried out to determine the economics of this project.

In February 1981 the Société Arabe de Mines de l'Inchiri (SAMIN) was formed to reopen the Akjoujt copper mine closed since 1978. The Mauritanian state holds 37.5 percent of the shares of this company. Sulphide reserves are estimated at 19,000,000 tons with an average grade of 2.5 percent copper with 1.2 grams gold per ton content. Planned production will be 105,300 tons per year of 25 percent copper concentrate.

MOROCCO

Despite the depressed international economic climate in 1982, the Moroccan mining industry saw a sustained level of activity in exploration, mine production, and mineral processing. Exploration was mainly aimed at solid fuels, precious and rare (strategic) metals, base metals, and

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Moroccan mineral production in metric tons

Commodity	1980	1981	1982
Phosphate rock	18,758,495	18,562,160	17,094,698
Coal	680,000	703,000	735,000
Iron ore	78,020	73,112	223,820
Manganese dioxide	130,662	109,647	94,120
Lead concentrate	171,377	168,406	148,515
Zinc concentrate	14,006	14,720	22,442
Cobalt concentrate	6,704	6,265	3,338
Copper concentrate	20,447	22,558	65,005[2]
Barite	358,311	465,660	537,955
Pyrrhotite	124,575	78,938	N.A.
Fluorite	64,400	66,700	50,200
Antimony ore	1,278	1,140	2,011
Silver precipitates[1]	24,897	22,055	27,013
Silver metal[2]	12,622	19,151	25,009
Lead metal	40,261	50,149	56,533
Copper matte	2,055	2,663	3,285
P_2O_5	573,811	738,734	1,015,169

1. Kilograms. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

industrial minerals.

For solid energy and fuel minerals the work covered uranium in Marrakech and Ourzazate provinces, and Jebel Saghro and the Middle Moulouya regions; lignite in the Guercif and Ghafsai sectors; and hard coal in the Djerada basin and the Taourirt region.

The prospecting programs for precious, special, and base metals covered several deposits and important reserves were identified. Notable amongst these were Roc Blanc and Jebilets in Marrakech province, Bou Maâdime in Errachidia province, Saghro in Ourzazate province, Tabekka in the Middle Atlas, Pays des Horsts in Oujda province, Jebel Khetem in Khenifra province, the central Anti-Atlas, the western Anti-Atlas, and the Middle Atlas.

In parallel with this prospecting for metallic ores, the Bureau de Recherches et Participations Minières also investigated industrial minerals. Notable prospects were barite at Bou Ouzzel and Amdrous, fluorspar at Zrahina in Khenifra province, magnesite at Boudkek in Chaouen province, bentonite at Nador, and perlite at Tidiennit.

In the phosphate sector the Meskala deposit was investigated by drilling. The Office Cherifien des Phosphates continued the development of its production and treatment facilities within the frame of its current five year plan 1981-1985. The Oued Zem treatment plant in the Khourigba district was inaugurated by the King in March.

The construction of the loading bins for the start up of the Recette IV and Bed II deposits at Mera El Ahrech continued on schedule. Dry beneficiation facilities for this rock are being planned. At Youssoufia several production sections were being equipped to start up. A process was selected for the calcination of the black phospate and OCP invited tenders. At Sidi Hajjaj beneficiation tests must be continued on this very heterogenous phosphate rock which will require flotation.

In other sectors of mining, 1982 was characterized by the opening of five new operations by the Minister of Energy and Mines:

The Bleida copper mine in Ouarzazate province which will allow the quadrupling of national production of copper ore (output 55,000 tons of 35 percent Cu concentrate). More than 300 persons are employed at the mine and live locally. The cost of the project was of the order of $40,000,000.

The Tiouit and Asfalou mines in Ouarzazate province. Tiouit will have an annual production of 1,560 tons of marketable concentrate containing 289 kilograms (9,300 ounces) of gold, 2,016 kilograms (65,000 ounces) of silver, 187 tons of copper and 202 tons of zinc. Asfalou will produce 1,080 tons of concentrate containing 3,888 kilograms (125,000 ounces) silver and 378 tons of copper. About 200 people are employed at the mines and the investment cost was about $7,000,000.

The Zgounder silver mine in Taroudant province will have a production of 73,000 tons of ore per year with a grade of 0.5 kilogram (16 ounces) silver per ton. The cost of the project, which employs 170 people, was $9,000,000.

The Sidi Lahcen mine in Oujda province will produce 5,567 tons of lead concentrate grading 74 percent Pb and 1.38 kilograms (44 ounces) silver per ton. Investment was about $9,500,000 and over 200 persons are employed.

OCP continued its planned activities for the downstream processing of its phosphate products. The fourth line of the Maroc-Phosphore I plant reached its nominal production capacity in 1982. Work continued on Maroc-Phosphore III and IV which will have a total production of 4,000 daily tons of P_2O_5. The Jorf Lasfar chemical complex will start production in 1984 and the Maroc Phosphore Nord project is planned to start up in 1986. In parallel with this activity the first phase of the project to recover uranium from the Maroc-Chimie and Maroc-Phosphore acid is progressing on plan.

A study is underway of plans to build a copper smelter in the Essaouira region to produce 45,000 tons of blister and 2,300 tons of refined metal per year. The possibility of smelting all the national output of lead concentrate in the Oued El Heimer smelter is also being studied.

Although the world recession has meant that output and sales of mineral products were reduced compared to 1981, transformed products such as phosphate chemicals and lead metal showed an increase. In effect, comparing 1982 to 1981, mine output showed a 7 percent tonnage fall and sales of mine products a 6 percent fall in tonnage terms and a 9 percent fall in value terms. For transformed products there was a 37 percent increase in production and 29 and 25 percent increases respectively in tonnage and value of sales.

NIGER

The mining industry, particularly the uranium sector, has been confronted by two problems during the current five-year (1979 to 1983) plan; maintaining production units at full capacity and receiving reasonable market prices for its products. Uranium production should have been increased by 142.6 percent by 1983 according to a 1978 report. However, output has not been raised by more than 65 percent. Molybdenum production is running below target (400 metric tons for 1983) because of problems in extracting moly from calcium molybdate. Cassiterite production which was to have been stablized at 100 tons a year has consistently fallen during the five-year plan period because of depleted reserves. Coal production will increase from 79,800 to 130,000 tons during 1983, against the planned increase from 97,000 to 200,000 tons. The phosphate beneficiation plant with a capacity of 6,000 tons a year has operated below capacity because of the poor market conditions.

A study to determine the mineral potential of Niger has defined a prospecting program for the whole country, for all minerals likely to be found in Niger. A mapping project is nearly finished and editing of 1:200,000 maps of the regions of Tillabéry, Téra, In Délimane, Kirtachi, In Gall, Agadès, and Ader Doutchi has commenced.

At the end of 1982 the total area covered by claims for mineral exploration was 44,616 square kilometers (17,223 square miles). At Afasto-ouest work carried out by Cogema, Onarem, and Ourd has delinieated reserves of 20,000 to 65,000 tons of uranium metal, with recoverable reserves of 25,000 tons. A pre-feasibility study will be prepared. The other uranium exploration projects were either cancelled, in the cases of Assamaka 1 and 2, Emilulu, and Tikikitene, or have not started, in the cases of Afasto-est, In Tadreff, and Damagaram.

Exploration at Iférouane has revealed a tin, iron ore (50,000,000 tons), titanium (20,000,000 tons) bearing area, as well as other various indications. For the time being this is not economic for commercial extraction.

The prefeasibility study of the iron ore reserves of Say should be completed by 1984. Reserves have been estimated at 20,000,000 tons containing 48 to 53 percent Fe.

The program to increase Société des Mines de l'Air's (Somair) production

capacity and modernize Compagnie Minière d'Akouta's plants has been accomplished. Each company now has a nominal production capacity of 2,300 tons of uranium metal. The realisation of the Smtt mining complex has been considerably delayed. The mine is to produce sufficient ore to give 1,300 tons of uranium metal annually. It will not be until 1985, now, that the first uranium is produced. The pre-feasibility study for the Abkorum-Azelik uranium project was completed in March 1979, but development has not yet started. Proven reserves are between 9,000 and 13,500 tons of uranium metal. It was planned that development of the Imouraren mining complex would not begin before 1983. However because of the market malaise, the mine will not go into production before 1990. The feasibility study had determined marketable reserves of 32,200 tons of uranium metal.

NIGERIA

There is need for greater industrialization in Nigeria. In this connection, the mineral resource potential of the country is being intensively explored, at a higher level than ever before. Before embarking on its development plan the government was well aware of the need to ensure local production of the raw materials required.

The National Steel Council Act of 1979 dissolved the Nigerian Steel Development Authority and established six companies which are to be involved in the country's steel development program. Five of these companies—the Ajaokuta, Delta, Katsina, Jos and Oshogbo Steel Companies were directly charged with the responsibility of producing steel or its by-products. The sixth company—the Associated Ores Mining Company Ltd. (AOMC) is to explore and develop the iron ore deposit at Itakpe Hill and other areas as well as related minerals necessary for steel production.

The Ajaokuta Steel Company Ltd. should be able to commission its blast furnace in September 1984 hence progress in mining the Itakpe Hill iron deposit is essential. At the moment there is very little indication that sustained supply of iron ore by AOMC can be guaranteed before September 1984. It is estimated that a reserve of 37 to 47,000,000 metric tons of iron ore is available at Itakpe Hill. A forecast of about 200,000 tons per annum furnace capacity is envisaged. The Delta Steel Company Ltd. was commissioned early in 1982 and has gone into production at about 960,000 tons of billets per annum.

Deposits of lead and zinc ores have long been known to occur in Nigeria but they have only been mined on a very small scale. Mining on a large scale has not been possible due to low metal prices, and lack of adequate finance, technology, and manpower. The Nigerian lead-zinc occurences extend for about 560 kilometers in a narrow belt 24 kilometers wide from south to the north in an easterly direction.

Drilling at Enyigba by the Nigerian Mining Corporation for lead-zinc ores has shown that the prospect extends in depth for hundreds of meters. The economics of commercial lead-zinc production is still being studied while exploration continues. Small scale mining in Abakaliki and Ishiagu areas produces about 1,500 tons of lead ores monthly for export.

Amalgamated Tin Mines of Nigeria Ltd. continued production of cassiterite and columbite concentrates from alluvial sources, although production falls from year to year. From April to December 1982 it produced and sold 1,924 tons of tin and columbite. Tin ore and columbite before the advent of oil boom were major foreign exchange earners for Nigeria. Uranium which has been found in Bauchi, Borno, Kano, Kaduna, Niger, Oyo and Plateau States is to be mined by the Nigerian Uranium Mining Company.

Extensive deposits of carbonate rocks are common all over the country. A few of them are currently being mined for various purposes. At Nkalagu near Enugu, Anambra state, over 110,000,000 tons of limestone exist. The Nigerian Cement Company has been the sole miner of this deposit since 1981. At Ewekoro in Ogun state about 35,000,000 tons of limestone have been proved and mined for cement production by West African Portland Cement Company. Between Ewekoro and the Benin border, an additional 100,000,000 tons of limestone has been reported. At Yandev in Benue State, there are more than 70,000,000 tons of limestone, with a seam thickness averaging 40 meters, being mined by the Benue Cement Company. There are several other limestone deposits being worked for cement production such as at Mfamosing in Cross River State where Calabar Cement Company operates, Gombe in Bauchi State where Ahaka Cement Company is working, and the Sohoto limestone deposit being mined by Northern Nigeria Cement Company.

Marble deposits exist in various places such as Jakura in Kwara state, Ukpilla in Bendel State, and Igbetti in Oyo state where they are mined for decorative stone and cement production. Clay deposits occur virtually everywhere and are extensively mined for the production of building bricks. The capacity of each brick works is about 20,000,000 standard bricks yearly. There are several in the country. Kaolin occurs in several localities in Nigeria both within and without the crystalline basement.

It is mined for the manufacture of chalk, insecticides, pottery and ceramic ware. Notable deposits are at South Ropp, and Werram in Plateau state where there is good silicious kaolin. Other occurences are at Agharansu and Ukpor in Imo and Anambra states, respectively. Glass sand deposits abound and three are currently being worked. The West African Glass Company at Port Harcourt mines the coastal beds of glass sand at Trans Amadi. At Aba, the International Glass Company Ltd. extracts the sand at Azumini River and the Ughelli Glass Company mines the Benin sands.

Other developments include explora-

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tion for salt for the establishment of chemical industries, coking coal and lignite for steel industries and quarry stones for construction. Overall the Nigerian Mining Corporation and the Nigerian Steel Council are responsible for the development of solid minerals in Nigeria.

RWANDA

Assisted by the Coopération Belge, the Direction des Recherches Gélogiques du Ministère des Ressources Naturelles continued in 1982 to work on establishing the geological map 1 to 100,000 started in 1981. This work will continue in 1983.

Another important event was the publication in 1982 of an ore deposit map of Rwanda (1:250,000) with the assistance of the Bureau de Recherches Gélogiques et Minières (BRGM).

Concerning mineral prospecting, BRGM continued its activities in the northeast zone of the country. The Projet de Recherches Minières of the United Nations continued prospecting the rest of the country.

With the financial assistance of the Canadian government an aerial survey took place in 1981. Ground verification will be finished by 1984.

As in the past ore production was undertaken by the Somirwa Company and small workers in the Gatumba (west), Rutongo (center-north), Rwinkwavu (east) regions for tin; and Gifurwe and Nyakabingo regions for tunsten. Some small workers produced a small amount of gold in the Nyungwe forest (southwest) and at Miyove (north).

The principle minerals mined are cassiterite, wolframite, columbo-tantalate, beryl and gold.

The tin smelter situated near Kigali was started up in 1982. It has a capacity of 3,000 tons a year. In 1982 it produced only 1,000 tons of tin due to a shortage of raw materials.

A cement factory situated in the south west of the country is being constructed with Chinese financial and technical aid. Its capacity will be 50,000 tons of portland cement per year and the reserves of the calcareous raw material (travertine) are estimated at 7,000,000 tons. It should be completed at the end of 1983.

SENEGAL

During 1982 a consulting consortium, headed by the French Socomine, presented its feasibility study of the Falémé iron ore deposits in eastern Senegal. The government has now reported that it will proceed with development. The reserves of magnetite, running 35 to 50 percent Fe, have been estimated at over 300,000,000 metric tons. The planned mining rate, 14,000,000 to 15,000,000 tons of run-of-mine ore, will produce sufficient ore for an annual export level of 12,000,000 tons of marketable ore for at least 23 years. The feasibility study estimated that the operating cost would be $6.00 per metric tons; a mining cost of $2.7 per ton, rail cost of $2.4 per ton, and port cost of $0.9 per ton.

The project will be managed by Mines de Fer du Sénégal Oriental. An investment of some $680,000,000 is expected. A railroad, between the port of Dakar and the mine, will cost some $400,000,000; port facilities will cost a further $136,000,000; and mine development will take the rest of the investment. The establishment of this infrastructure could open up posibilities for the development of phosphate and marble deposits in the same area.

At present, phosphates, both calcium and aluminum, and attapulgite clays are the primary minerals produced in the country. Compagnie Sénégalaise des Phosphates de Taiba (CSPT) produces calcium phosphate, with a market output of 1,800,000 tons a year. The other producer, Société Sénégalaise des Phosphates de Thiès (SSPT) mines aluminum phosphate, calcium phosphate, and attapulgite. Production of raw aluminum phosphate is 600,000 tons a year and calcium phosphate, 180,000 tons a

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year. The attapulgite mining operations began in 1980 and currently produce some 90,000 tons annually but this level is being raised to 200,000 tons by expansion measures currently in progress.

As usual throughout West Africa, Bureau de Recherches Géologique et Minières (BRGM) is active in Senegal. Exploration work last year indicated two mineable, rich phosphate ore bodies in the region of Fleuve and Casamance. Prospecting of the Sabodala prospect resulted in an increase in possible reserves to between 7,000 and 8,000 kilograms (225,050 and 257,200 ounces). Other gold exploration continues.

SIERRA LEONE

The country's economy deteriorated during 1982 consequent on worldwide inflation and the general downturn in trade. There was serious erosion of the country's foreign exchange reserves, business activity contracted and there were low prices for export commodities and huge expenditure of foreign exchange on imports. The mining industry was seriously affected since it was not able, for lack of foreign exchange, to import needed machinery and spare-parts. To add to the industry's problems, world demand for its products slumped and there was a fall in the price of diamonds, rutile and bauxite. The National Diamond Mining Company (S.L.) Ltd, Sierra Rutile Ltd and Sierra Leone Ore & Metal Company, particularly the former two, had no alternative but to lay off personnel. A large number of expatriate and local senior employees and plant staff had to be made redundant.

Total diamond production by the National Diamond Mining Company was 187,352 carats, 13,873 carats of which came from kimberlite. There were higher yields from the alluvial diamond areas mined, hence the increase over the 1981 production figure of 145,325 carats. A total of 119,632.23 carats were exported in 1982 under the Alluvial Diamond Mining Scheme.

In the unmined areas and current mining blocks in the Yengema and Tongo leases, illicit mining continued but was contained by company security. During the year negotiations continued between the Government and Sierra Leone Selection Trust for an agreement on kimberlite mining.

In January 1982, the Sierra Leone Ore & Metal Company started production at Gondama where it has also recently commissioned a new washing plant. The company produced 630,100 metric tons of bauxite and shipped 605,867 tons in 1982. The quantity shipped fell far short of expectation and was an indication of poor market conditions for bauxite.

Sierra Leone mineral production in metric tons

Commodity	1980	1981	1982
Diamonds[1]	504,245	465,627	306,984
Bauxite	830,500	615,884	630,100
Rutile	52,573	53,481	46,576

1. Carats. 1.0 metric ton = 1.10 short tons. 1.0 short ton = 0.907 metric ton.

Sierra Rutile Ltd produced 46,576 tons of rutile and exported 50,044 tons in 1982. The annual rate of production for the last twelve months of full production was 76,417 tons. The plant performed at or above design in all other respects during the whole period (metallurgical performance, plant rutile recoveries, mechanical availability and operating hours). Grade of ore was below expectation, 1.46 percent recoverable rutile instead of 1.8 percent, leading to lower production.

Towards the end of the first half of the year world demand for paint pigment and titanium metal became seriously depressed resulting in loss of contracted sales over the rest of 1982, and the mine had to be closed down in July followed by huge staff redundancies. During the period when the plants were idle, regular and major maintenance was carried out on all units. The ownership of the mine passed to Nord Resources of Dayton, Ohio, the former minority shareholder, which acquired the 85 percent shareholding of Bethlehem Steel Corporation. It became the sole owner of the mine at the end of October. The mine was expected to recommence production after the conclusion of negotiations between government and Nord Resources early in 1983.

Construction work and commissioning were completed during the year by Marampa Iron Ore Mining Company making it possible for the mine to be officially opened in December. On the day following the opening ceremony, the first trainload of iron ore concentrate left for Pepel, the loading port, about 50 miles by rail from Marampa. The train carries about 2,000 tons (40 trucks of 45 tons each) and should make two trips a day. Shipments of ore started early in the new year.

The Bank of Sierra Leone, the only authorised exporter of gold in the country exported 10,031 ounces in 1982. A Total of 49 gold mining licences were issued; 41 gold buyers licences were issued to citizens and 11 to non-citizens.

SOMALIA

Commercial mining in the country is currently restricted to the production of meerschaum from deposits in the Mudugh region near El Bur, about 350 kilometers (220 miles) north east of Mogadishu and 130 kilometers (80 miles) from the coast. The material is high-porosity, low-density sepiolite. Current exports are estimated at about 9 metric tons per year.

In the same region there are carnotite uranium ore bodies, discovered by the United Nations Development Program (UNDP) in 1974. A report released last year by the Organisation for Economic Cooperation and Development (OECD) and the International Atomic Energy Agency (IAEA) states that Somalia has reasonably assured uranium resources of 6,000 metric tons of metal content in a cost range of $80 to $130 per kilogram with an additional 6,600 tons of reasonably assured resources in excess of $130 per ton. About half as much again is considered as estimated additional resources. However, the world market being what it is, no commercial mining is expected to be undertaken this century.

Tin placer deposits have been worked at Dalan and veins mined at Majayahn where an ore dressing plant was constructed in the 1970's. Iron, nickel, chrome, and other base metal mineralization has been noted by UNDP programs that are continuing.

The first cement plant is being completed near Berbera on the north coast. A second plant is planned to support construction of the Bardera hydro-electric dam in the Juba River valley near Kenya.

SOUTH AFRICA

After several years of record production and record sales figures, the South African minerals industry in 1982 experienced the full impact of the recession affecting its major trading partners. Nevertheless, the industry once again demonstrated its basic strength and ability to weather adverse trading conditions.

In 1982 the industry again made a major contribution to the country's economy. Earnings from total mineral sales amounted to $13,327,000,000, an increase of 5.7 percent over the final figure of $12,612,000,000 recorded in 1981. Income generated by exports totalled $11,129,000,000, some 4.3 percent more than the 1981 total of $10,673,000,000, and accounted for 83.5 percent of all mineral earnings.

Earnings from gold constituted nearly 73 percent of total revenue from mineral exports. The gold price, heavily influenced by high interest rates in the United States and increased gold sales by the Soviet Union, was down 18.3 percent on the previous year. Despite this, the value of South Africa's gold sales reached $8,100,000,000 (2.6 percent up on the 1981 total), thanks mainly to the advantageous Rand/United States dollar exchange rate in 1982, coupled with slightly higher production.

The recession led to production cuts of platinum group metals and certain ferrous and non-ferrous metals. Total non-gold exports rose in value by 9 percent to $3,030,000,000, and was largely

South African metal and mineral production in metric tons

Commodity	1980	1981	1982
Gold[1]	674,000	656,000	662,516
Silver[1]	98,950	235,393	215,956
Diamonds[2]	8,593,806	9,525,900	9,153,990
Copper	199,879	199,424	188,709
Tin	2,914	2,811	3,035
Antimony concentrate	22,372	16,599	15,314
Chrome ore	3,296,969	2,869,502	2,163,973
Iron ore	22,911,987	28,318,856	24,553,600
Lead concentrate	N.A.	98,901	90,288
Zinc concentrate	N.A.	87,172	91,516
Manganese ore	5,710,839	5,839,687	5,216,517
Asbestos	268,536	235,943	211,860
Fluorspar	504,981	496,521	330,835
Uranium oxide	6,146	7,234	6,863
Phosphate concentrate	N.A.	1,085,990	2,814,656
Coal	103,767,866	122,729,490	130,267,209
Coal	122,729,490	130,267,209	140,137,421
Gypsum	442,896	554,827	534,991
Limestone and lime	15,000,000	23,378,386	22,378,789
Silica	1,400,000	1,386,848	1,259,510
Vermiculite	185,699	190,801	182,641

1. Kilograms. 2. Carats. N.A. Not available. 1.0 metric ton = 1.10 short tons. 1.0 short ton = 0.907 metric ton.

attributable to increased coal export earnings. Diamonds, platinum, uranium, copper, iron, and manganese were major contributors.

Local mineral sales increased in value from $1,940,000,000 in 1981 to $2,198,000,000 in 1982. Earnings from coal sales, totalling $1,287,000,000, provided by far the largest share (58.5 percent) of this amount. Other major revenue earners included copper, manganese and iron ore, phosphate concentrates, and limestone and dolomite products.

The average gold recovery grade, at 6.76 grams (0.21 ounce) per ton, represented a decrease for the tenth consecutive year. This is in line with the policy to mine lower grade ores wherever possible and thus extend the life of the industry. As a result of the commissioning of new milling units, the volume of ore treated increased to 95,000,000 metric tons. Gold production was higher at 662.5 tons, compared with 655.8 tons in 1981. The Rand Mines dump retreatment and recovery plant started production in the first quarter of 1982.

Production of uranium oxide for 1982 was 6,862 tons (containing 5,816 tons of uranium). This is 5.2 percent lower than the 1981 production of 7,235 tons (6,131 tons U). This slight decrease in production is attributable to the depressed state of the world market experienced over the last three years.

The depressed market has caused some producers to either cut back on their planned 1982 production or to phase out production temporarily, as in the case with West Rand Consolidated Mines and the No. 1 Plant at Western Deep Levels. This production loss has been offset by the commissioning of new uranium plants at Western Areas and Beisa Mines with their combined production accounting for 6.2 percent of 1982 production. At Afrikander Lease the uranium plant was completed, but immediately placed on care and maintenance. South African producers are well placed to take full advantage of an improvement in the market expected in the mid 1980's.

Demand for diamonds was down for the more expensive gems and relatively small quantities were offered to the market. In an attempt to maintain the supply/demand balance, De Beers closed the Koffiefontein mine in the Orange Free State and reopened the Tweepad mine in Namaqualand. Although total diamond production in 1982, at 9,153,990 carats, was slightly less than in 1981, there was a marginal improvement in total earnings.

Silver production fell by 8.3 percent to 216 tons, mainly as a result of lower output of lead concentrate. Silver prices, moving in sympathy with those of gold, were substantially lower than in 1981. Export earnings declined by 3.6 percent to $46,500,000.

The state of the world's platinum industry was reflected by production cuts of up to 20 percent by the country's major producers. Production levels of nickel, a byproduct, declined in line with the reduced platinum output. The value of nickel exports fell by 30.6 percent to $37,000,000.

As a result of the world steel recession, tonnages of iron ore exports were below the levels of 1981. Domestic sales held up remarkably well over the first three quarters of 1982 but the last quarter saw a decline as a result of production cuts by Iscor—this was also reflected in the closure of coal mines supplying coking coal to Iscor. Earnings from iron ore exports and local sales were $216,600,000 and $121,300,000.

The value of both export and local sales of manganese ore improved substantially. Export earnings rose by 15 percent to $124,500,000, representing a marked increase in the average price realised. The value of local sales rose by 17.6 percent to $52,500,000.

The demand for stainless steel, refractories and chrome chemicals—the major outlets for chrome ore—was severely depressed during 1982. Export volume and earnings declined by 45.6 and nearly 38 percent respectively, to 549,162 tons and $25,800,000.

In terms of sales value, which amounted to $275,500,000, copper was the most important non-ferrous metal produced in 1982. Production declined during the second half, so that more copper was available for export. Local sales and exports were valued at $126,600,000 and $148,900,000, respectively.

Black Mountain Mineral Development Company, South Africa's only primary lead producer, exported its entire output as concentrate. Owing to weak demand, there was a fall in world prices and export earnings declined by 10.2 percent. Of the zinc concentrate produced by Prieska Copper Mines (Pty) Ltd. and Black Mountain, a portion was refined domestically and the balance exported. The metal content of concentrate processed locally declined marginally to 53,834 tons. Exports increased substantially to 34,182 tons.

Mine production of tin increased by 8 percent to 3,035 tons. Owing to weak domestic demand, local sales decreased by 14 percent to 1,138 tons, so that a larger quantity was available for export. Most of the tin exported (61.6 percent) was in the form of refined metal. The value of exports, just over $20,000,000, increased by 56.2 percent.

Consolidated Murchison Ltd. exports both concentrate and crude antimony trioxide. Overseas demand for antimony products was very weak in 1982 and the mine had to run at reduced capacity throughout most of the year.

Asbestos exports were $90,300,000, 8.8 percent lower than in 1981. Exports of rutile rose in value by 13.6 percent despite weak world demand. During the year Richards Bay Minerals Corporation commissioned a new $18,500,000 extraction pond and concentrator.

SOUTH WEST AFRICA

Production of ore from Rössing Uranium Ltd.'s open pit was once again reduced, from 14,903,000 metric tons in 1981 to 14,238,000 tons in 1982. Uranium oxide production also fell from 4,682 to 4,456 tons. Inspite of the production decline, unit costs increased less than the local average. The mine was able to reduce fresh water consumption significantly, mainly due to recycling.

Rössing, in 1982, represented assets of $358,700,000, or 4.4 percent of its parent company's (Rio Tinto Zinc) total assets. Rössing's turnover in 1982 was $341,800,000, 5.5 percent of RTZ's total turnover. It made a pre-tax profit of $14,300,000 (26.8 percent of the total) and a net profit of $50,660,000 (25.8 percent of the total). This represents a substantial increase over the net profit in 1981 of $33,566,000 (17 percent of the total).

Due to the poor market for diamonds that continued for most of 1982 CDM (Proprietary) Ltd., in order to achieve further economies without reducing sales, cut production levels below those originally planned at the beginning of 1982. No. 3 conglomerate crushing treatment plant, the 50 G sampling plant, and the two field screening plants remained closed throughout the year and the 100 G smapling plant was closed at the end of February.

Diamond production was 19 percent lower than in 1981 at 1,014,464 carats. Total tonnage treated by the three oper-

ating conglomerate crushing treatment plants was 10,018,000 at an average grade of 10.13 carats per 100 tons, compared with 12,544,000 tons at a grade of 9.95 carats per 100 tons in 1981. Overburden stripping in 1982 was significantly reduced, to 18,435,000 tons compared with 37,698,000 tons the previous year.

A wide-ranging and, in places, intensive prospecting program continued and although several kimberlites were discovered, none is of economic interest. However, in the south along the north bank of the Orange River, testing of gravels continued to give encouraging results. Off the coast systematic sampling of the ocean floor continued using two specially equipped vessels. A third vessel carried out geophysical surveys.

For the financial year 1981/1982, the Rosh Pinah mine produced 54,500 tons of zinc concentrate and 13,800 tons of lead concentrate. The Uis tin mine produced 1,155 tons of concentrate. The operating company of both mines, South African Iron and Steel Industrial Corporation, Ltd. (Iscor), reports that promising indications of lead, copper, and zinc were discovered north of Rosh Pinah, and these are currently being examined.

Tsumeb Corporation Ltd. sold a total of 28,650 tons of lead from its own mines and 9,150 tons of custom metal during 1982. It also sold 34,380 tons of mined copper and 2,120 tons of custom metal. Total silver sales, including customer metal, amounted to 87,465 kilograms (2,812,000 ounces). At the Tsumeb mine, 385,118 tons of ore averaging 3.2 percent Cu, 6.7 percent Pb, and 1.8 percent Zn were mined and milled.

In the Kombat/Asis West mine area mining operations in the lower grade Kombat No. 3 shaft and central sections were suspended due to poor metal prices, while production from the high-grade Asis West section was increased. Ore production was 291,429 tons, averaging 4.2 percent Cu and 1.9 percent Pb. During the latter part of the year, significant mineralization was intersected by drill holes exploring the deeper Asis West section. The Matchless mine milled 122,741 tons of ore averaging 2.3 percent Cu.

Tsumeb now has a 70-percent joint venture interest in the Otjihase mine. The 16-month rehabilitation of the mine was completed and it resumed production at a milling rate of 65,000 tons a month in April. In September the production rate was increased to 80,000 tons to offset partly the loss of copper production from Tsumeb. A total of 769,290 tons of ore, averaging 2 percent Cu were mined and milled, compared with 206,902 tons in 1981.

Falconbridge Ltd. sold its 74.9 percent share in the copper-silver operations of Oamites Mining Co, as a result of dwindling reserves at its two mines and recent losses. At the end of 1981, proven and probable reserves amounted to 2,027,000 tons grading 1.13 percent Cu. The purchaser was Metorex of South Africa. Production at the Swartmodder mine was suspended in March because of the low copper price and unexpected geological and mining problems. At the same time production at Oamites was reduced from 45,000 to 35,000 tons a month.

During the year, Natresco (Pty) Ltd. reported discoveries of tantalite-columbite, grading up to 50 percent Ta_2O_5, in the vicinity of Tantalite valley in the south of the country. Natresco is now seeking joint venture partners with a view to establishing a mine.

SUDAN

Since 1968 the Sudan Geological and Mineral Resources Department has been carrying out geological mapping and mineral exploration. Some gold and chromite mines have been reopened and new iron, manganese and gypsum mines developed. Mines operating at present include the chromite mines of the Ingessana Hills, the mica mines in northern province, and the gypsum mines of the Red Sea Hills.

All are operated by the Sudan Mining Corporation which was established in 1975 and is now adopting an ambitious program to improve the existing mines in order to increase production, and to establish new mines in joint ventures with foreign expertise. Proposed mines include gold, asbestos, and wollastonite and industries for the production of sodium bi-carbonate, ferrochrome, kaolin, and lime.

Minex Corporation of the United States signed an agreement with government to start gold mining in the Red Sea Hills. Initial work will concentrate on the old mine at Gebeit, which was a significant producer until the 1940's. Mining of other, nearby deposits is expected to start soon.

Also in the Red Sea Hills, a pilot tungsten mining project has started at Jebel Gash Amir, near Derudeb. If reserves prove sufficient, full-scale development will be undertaken.

Bureau de Recherches Geologiques et Minières (BRGM) is continuing with exploration work in the Red Sea Hills. Mineralization in this area includes gold, copper, iron ore, chromite, asbestos, lead and zinc, vermiculite, wollastonite, and tin-tungsten. Iron ore has been reported in 21 locations with resources ranging from 88,000,000 to 15,000,000 metric tons and Fe contents from 40 to 60 percent. They could be mined, despite their small size, because they are reasonably good grade and close to the sea. None of the other mineral showings are likely to be developed in the near future, either because they are too small or because more evaluation is required.

Hofrat en Nahas in south western Darfur province is considered to be the most promising copper deposit in the country. Reserves are estimated to be about 10,000,000 tons containing 2.8 percent Cu.

TANZANIA

Work on the Buck Reef gold mine, in the Geita district, is continuing. The mine is to be operated by the State Mining Corporation (Stamico) with a management team and back-up, including mine, engineering, and processing superintendents, supplied by LKAB International of Sweden. When in production, annual output is expected to be around 284 kilograms (10,000 ounces) of gold per year. Last year, it was reported that another gold mine was being developed at Chunya, north of Lake Malawi, with a planned output of 160 kilograms (5,140 ounces) of gold per year. No further information has been received on this project.

The Minjingu phosphate mine and beneficiation plant in the north of the country, 100 kilometers (62 miles) southwest of Arusha, went into production in December 1982. The project was developed by Kone Corporation's engineering division and has now been handed over to Stamico. The design capacity of the beneficiation plant is 100,000 metric tons of phosphate concentrate per year, containing a minimum of 30 percent P_2O_5. Mining is a shovel and truck operation, no blasting is required.

Indicated reserves of the Minjingu deposit amount to 10,000,000 tons of ore within 60 meters (196.85 feet) of the surface. Mining calaculations were based on the extraction of the three first ore beds in the north of the deposit with reserves of some 1,400,000 tons containing 24.6 percent P_2O_5 on average.

Expansion of the kaolin open pit mining operations at Pugu, some 40 kilometers (25 miles) from Dar-es-Salaam, was in progress last year. This is intended to raise production from about 3,000 metric tons a year to 5,000 tons. Other projects being considered are the iron ore potential of Mchuchuma, with technical assistance from West Germany, and the open pit mining potential of a gypsum prospect at Kilwa on the coast, some 250 kilometers (155 miles) south of Dar-es-Salaam. Exploration of this prospect has been carried out, for Stamico, by LKAB International.

TOGO

The five-year plan for 1982 to 1986 includes 10 mineral projects for which almost $6,000,000 have been set aside. In this program, the Nayega manganese prospect is to be examined in more de-

tail, including geochemical prospecting and exploration drilling. The reserves are estimated to be at least 10,000,000 metric tons at a grade of 10 to 35 percent. A program of geochemistry and 23 exploration holes is planned for the copper-nickel sulphide prospects of Yadé-Bohou, Assiré-Somdé, and Farendè. Further work is also to be carried out on the Farendè chromite prospect. Proven reserves have been calculated at 30,000 tons containing 25 to 35 percent Cr_2O_3.

There is to be a general study of chromite and iron ore deposits to evaluate national resources. The iron ore deposit of Bandjéli-Bassari should not be compared with the great deposits of Africa, such as Nimba, Falémé, or Belinga, already being mined or under investigation but the government feels that it merits extra investigation relative to regional economics. The deposit is in the area of Bassari, 360 kilometers (224 miles) from Lomé, close to Ghana. The only well studied part of the deposit is a chain of hills 6 kilometers (3.7 miles) long. Work carried out in 1966 determined that the proven reserves of these hills amount to 45,000,000 tons and the probable reserves, 95,000,000 tons. These hill will be the primary exploration target.

Other work to be carried out ir cludes geological mapping between the tenth and eleventh parallels, an area that is little known. Geological maps of the whole country, at 1 to 200,000 and 1 to 50,000 are to be produced. Geological mapping and prospecting is also to be carried out between the ninth parallel and the coastal sedimentary basin, a region rich in mineral showings but poorly explored. Prospecting will concentrate on silver, gold, lead, zinc, copper, and chrome. Also a geological evaluation is to be conducted based on exploration holes already drilled in the coastal sedimentary basin. This work is to orientate the search for lignite, diamonds, and gold.

Finally an evaluation of the country's marble and ornamental stone deposits is to be carried out. This will concentrate on the dolomite of Gnaoulou, reserves about 18,000,000 tons; the dolomite of Nagbon, reserves 8,000,000 tons; the dolomites of Pagala and Kpékplémé, and the Dapaong pink granite deposit. The reserves of the latter have not been estimated but they are reported to be very significant.

The geological depratment continues with exploration for base metals and uranium. At the beginning of last year a partnership with three Swiss companies to establish a Togolese attapulgite and bentonite company. One of the company's first tasks is to find export markets for a known attapulgite deposit, of about 20,000,000 tons, situated at Aveta, 30 kilometers (18.6 miles) from Lomé.

The country's major mineral production remains phosphate, currently running at around 3,000,000 tons a year. Reserves in the country are estimated to be some 100,000,000 tons.

TUNISIA

Tunisian production of base metal concentrates, industrial minerals, phosphate, etc. is shown in the accompanying table. It will be noted that output of several commodities increased in 1982 compared to 1981.

Prospecting work is mainly carried out by the Office National des Mines. In the Zaghouan fluorspar region the ONM reports confirmation of 2,500,000 tons grading 23 percent CaF_2, 35 percent $BaSO_4$, and 2 percent Pb-Zn at the Guebli deposit. There are an additional 2,000,000 tons of possible reserves. Studies of mining methods and processing flowsheets of the ore are underway.

In central-north Tunisia the ONM along with the French Bureau de Recherches Géologiques et Minières are conducting the evaluation of the Kebbouch-Bougrine deposit. Known reserves are 2,200,000 tons grading from 3 to 12 percent Pb-Zn. Preparations for mining are underway.

In the Chambi region a six year program (1981-1986) investigating old workings where barite and lead-zinc ores were mined, is continuing. The ONM, in collaboration with the Scientific Research Institute, is making a 21 sheet, 1/100,000 geological map of the whole country. A systematic inventory of industrial minerals such as clays, sands, limestone, dolomite, etc. is also being conducted.

Uranium prospecting has taken place in Tunisia since 1976. Anomalies have been discovered in South Tunisia and in the volcano-sedimentary structures of Oued Belif in northern Tunisia. Investigations are also being made of the distribution of uranium in Tunisian phosphate ores.

The feasibility study to extract potash salts from the Sebkhat el Melah brines in southern Tunisia has led to the formation of an operating company. ONM is now investigating other brines. The Compagnie des Phosphates de Gafsa is also investigating the Chott Jerid brines. These are highly concentrated at surface and become dilute at depth. They could possibly contain several tens of millions of tons of potash.

Tunisian production of ores and concentrates in metric tons

Commodity	1980	1981	1982
Silver[1]	7,332	2,621	n.a.
Lead concentrate	14,245	9,703	8,618
Zinc concentrate	16,298	14,096	15,455
Bulk concentrate	2,327	1,082	1,252
Fluorite	39,451	34,844	36,180
Barytine	26,949	24,671	33,613
Iron	389,485	395,952	271,073
Phosphate ore	7,780,003	8,481,427	8,288,490

1. Kilograms. N.A. Not Available. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric ton.

The Société Minière Metallurgique de Tunisie along with Bulgargeomin (Bulgaria) and BRGM is engaged in a program for determining the potential reserves of all the deposits and prospects in the Fedj-Hassene region of Northwest Gardiamaou. Proved and probable reserves are close to 623,000 tons grading 9 to 14 percent zinc. Possible reserves are 460,000 tons between 9 and 15 percent zinc.

Société Tunisienne de d'Expansion Minière (Sotemi) has been exploring round several of its mines which are becoming exhausted and has launched feasibility studies on additional reserves at Sidi Dries, Fedj El Adoum, and Bou Jaber.

The iron ore producer Société du Jebel Jerissa reports that the possibilities of increasing its hematite reserves are limited. The quantity of iron carbonate minerals is large, but the grade is only 15 to 25 percent Fe.

The phosphate mining company Compagnie des Phosphates de Gafaa is investigating down dip extensions of its existing deposits in the Gafaa basin. It is also prospecting unmined deposits in the region, particularly those which could be open pitted. These account for several hundred million tons of phosphate. Exploration is also being conducted in the Meknassey Basin between Meknassy in the south and Sidi Nasrallah in the north. Triassic domes make the structure complex.

Possible reserves are about 50,000,000 tons divided into several deposits. In the northern phosphate basin investigations are being carried out on the possible open pit mining of proven reserves of 2,000,000 tons of phosphate. A potential deposit of 2,000,000,000 tons at Sra El Ouertane is also being prospected. Other work at the Kalaa Khasba mine has resulted in 5,500,000 tons of phosphate being confirmed.

UGANDA

During 1982 the government remained stable and stuck to its firm economic measures adopted in 1981. As a result the economy is beginning to improve. After growing by 7.5 percent during 1982, the gross domestic product is expected to increase by a similar amount in 1983. Included in a government recovery program presented in 1982 is a project to assess Uganda's mineral potential. For the few existing mines, emphasis is being placed on feasibility studies, as most are not producing at present.

The Kilembe copper-cobalt mine is still on care and maintenance. Some copper concentrate production, barely 2,000 tons, was possible last year through the 30-ton-an-hour extension plant. The

main 90-ton-an-hour milling plant remained inoperative due to lack of spares. Any substantial improvement in the Kilembe situation will not be possible without substantial investment.

Seltrust Engineering carried out a feasibility study of the Kilembe mine, concentrator and smelter, and cobalt and sulphuric acid plants. The completed report was presented to the government in January this year. European Investment Bank paid for the study.

Elsewhere, Sofremines, at the head of a French consortium is carrying out a feasibility study of the Sukulu Hills phosphate deposit. A fertilizer plant, operated by Tororo Industrial Chemicals and Fertilizer Co. is located in Tororo district but ceased production early in the 1970's. The government wishes to get this facility back into operation as soon as possible. The project could also be linked to Kilembe as the latter's sulphuric acid could be used in the manufacture of phosphate fertilizers.

The Sukulu Hills deposit also contains some iron ore. Some studies were carried out on the iron ore and other by-products including columbium, in the 1950's and 1960's. Madhvani International which operates a steel plant at Jinja, using local scrap, as expressed interest in the ore as a pellet source.

Reactivation of small mines, mainly tin and gold, is being attempted but so far with very little success due to manpower and equipment shortages. There are still plans to set up a National Mining Corporation to stimulate mining development and legislation may be introduced this year.

The Lake Kature salt project, commissioned in December 1980, has so far been a complete disappointment with absolutely no production. An agreement has been reached with West Germany for a loan to modify the plant.

UPPER VOLTA

Serious attempts are being made to diversify the country's economy from its heavy dependence on agriculture, which is very prone to failures through drought. Development of a mining sector is one area receiving a great deal of attention. A key project in this drive is the reopening of the Poura gold mine, 180 kilometers (110 miles) south west of the capital Ouagadougou. The mine was last operated in 1966.

The ore averages 15 grams of gold per ton and estimated total reserves are 23 metric tons of contained gold. Mine production is to be at a rate of 2.5 tons of gold per year and total capital investment has been estimated at $100,000,000. Recent discoveries of additional gold deposits in adjacent areas could extend the mine's life by several years. The project is being managed by Société de Recherche et d'Exploitation Minière (Soremi).

In the north of the country, Société des Mines de Sahel (Somisa) plans to begin gold production at the small Guiro and Bayildjaga mines, not far south of Dori. BRGM is carrying out feasibility studies on gold prospects at Diouga near the other two mines.

BRGM is also studying gold prospects at Bouroum in the north. Other gold prospects are being evaluated at Kwademen in the Tenado region following their discovery by a joint United Nations Development Program and government team. Elsewhere, Bureau de Recherches Geologiques et Minières (BRGM) is carrying out work on gold mineralization in the Gangaol region.

There are significant phosphate reserves. The most important deposit is at Kodjari in the east where reserves are some 80,000,000 tons containing between 18 and 33 percent P_2O_5. Mining is already carried out here at a rate of about 3,000 tons per year. Smaller but richer deposits exist at Arly and Aloub Djouna.

A $350,000,000 project to develop a manganese mine at Tambao in the remote north east has been postponed. The major factor in this decision was the high cost of building a 340-kilometer (212-mile) railroad with a terminal at Ouagadougou. This is a major stumbling block to much of the potential mining development in the country; that most of the mineral resources are in the north, about 1,500 kilometers (940 miles) from the sea.

Government is studying small-scale mining of copper, lead, bauxite, and nickel prospects. However a recent report indicates that any such development will be handicapped by current low metal prices and the high cost of setting up the necessary infrastructure. The World Bank is also carrying out similar studies on sulphide deposits at Perkoa containing zinc, silver, and lead. Mining of antimony at Mafoulou and chrome at Tiara continues.

Four diamond structures have been found in the northern Barsalogo region by BGR Hanover. Traces have also been found in the Zabre-Gog region in the south east.

ZAIRE

By **Vladimir Pletser**
Kinshasa University

Apart from the production of zinc and cadmium, mining activity in Zaire in 1982 declined in comparison to 1981.

Copper production, which accounts for 80 percent of Zaire's foreign exchange earnings, showed a slight reduction to 502,877 metric tons in 1982 compared to

Zairean mineral production in metric tons

Commodity	1980	1981	1982
Cadmium	168	230	282
Coal	137,314	129,391	123,683
Cobalt	14,482	11,124	5,608
Colombotantalite	82	80	60
Copper	460,007	503,376	502,877
Diamonds	10,233,815	6,763,347	6,043,910
Gold	1,271	2,004	1,935
Lead vanadate	500	400	421
Manganese	6,321	18,214	—
Monazite	51	35.2	31
Silver	78,824	80,254	54,443
Tantalum slag	100	105	92
Tin cassiterite	3,160	3,291.8	3,144
Wolframite	134	88.6	74
Zinc ingot	43,848	57,633	64,397

1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric ton

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503,376 tons in 1981. Copper production has thus been in continual decline since 1979 when there was an important fall in output.

Gecamines, which is the most important mining company in Zaire, maintained its 1982 production of copper at 467,000 tons just below the maximum capacity production of 470,000 tons achieved in 1981 and previously in 1974. Sodimiza, an 80 percent owned subsidiary of Nippon Mining Co. Ltd., produced 81,000 tons in 1982 compared to 87,000 tons in 1981. Gecamines cobalt production fell by 50 percent compared to 1981, 5,600 tons down from 11,100 tons (14,500 tons in 1980). The reason for this is the deliberate reduction in output decided by the company. In addition, in September 1982 the Zairean news media reported the extraordinary disappearance of a large quantity of cobalt.

The only positive element in Zaire's mining picture in 1982 was the increased production of zinc and cadmium by Gecamines. The 1982 zinc production of 64,400 tons is the highest level achieved for more than 10 years. The 1982 cadmium production of 282 tons compares to 230 tons in 1981 and 168 tons in 1980.

After the very sharp fall of production of more than 60 percent in 1980, the Office des Mines d'Or de Kilo-Moto returned to normal production levels in 1981 but showed another fall of 22 percent in output in 1982. Production of fine gold amounted to 1,046.5 kilograms in 1982 compared to 1,350 kilograms in 1981 and 602 kilograms in 1980.

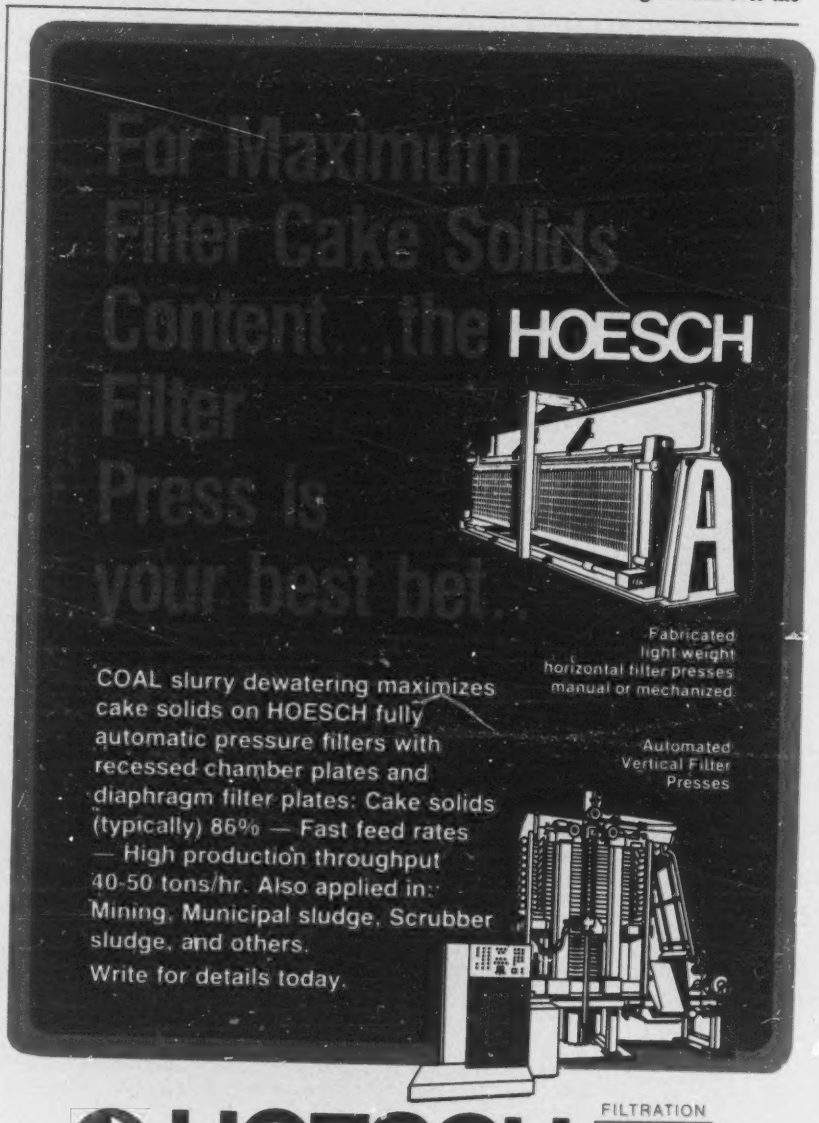
Société Minière du Kivu (Sominki) also showed a fall of 20 percent in its fine gold output from 531 kilograms in 1981 to 429.3 kilograms in 1982. This is accounted for by the gold theft in June 1982 when two members of the security department of the Mines d'Or de Kamituga (Kivu) who managed to secretly to make off with 60 kilograms of gold while ostensibly transporting a shipment of another 52 kilograms of gold.

Only Gecamines showed an increase of gold production which was 20 percent higher, 123.8 kilograms in 1982 compared to 103 kilograms in 1981. Various small workers and individuals are claimed to have accounted for a production of 336 kilograms of gold in 1982 compared to only 20 kilograms in 1981—a somewhat remarkable increase.

Silver production also fell by 32 percent in 1982. Gecamines produced 54,347 kilograms of silver in 1982 compared to 80,119 kilograms in 1981. Office de Kilo-Moto and Sominki produced 91,000 and 15,000 kilograms respectively in 1982 compared to 117,000 and 18,000 kilograms in 1981.

Although still the world's most important industrial diamond producer, Zaire has seen various declines in activity in recent years. In May 1981 the Société Zaïroise de Commercialisation de Minerais (Sozacom) terminated the exclusive contract which the Central Selling Organization held for marketing Zairean diamonds. In 1982 the Zairean authorities decided to liberalize trade in precious stones in Zaire and to strengthen legislation regarding the presence of expatriate nationals in the mining areas. This policy obviously was of benefit to the income of the diamond mining companies and the Zairean public treasury. Thus Minière de Bakwanga (Miba) produced 5,656,096 carats in 1982 compared to 5,753,568 carats in 1981 and over 8,000,000 carats in 1980. These figures are still far below the record production achieved in 1974 of 30,500,000 carats.

Some 70 percent of Miba's production consists of industrial diamonds. In July 1981 Sozacom took over the diamond companies Britmond in Kinshasa and Meltax in Tshikapa. Some 60 percent of the Tshikapa diamonds are gem stones. In 1982 Sozacom showed a fall of 58 percent in diamond sales, 423,351 carats in 1982 compared to 1,009,779 carats in 1981. Thus the total Zairean production of diamonds fell from 10,233,815 carats in 1981 to 6,763,347 carats in 1982—a fall of 40 percent. The optimistic forecasts of Miba (13,000,000 carats by 1983) may be reviewed following the announcement in March 1983 that the Central Selling Organization would once again take over the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marketing of Zairean diamonds.

Tin production in 1982 also showed a sharp fall of 22 percent. Sominki which produces more than 80 percent of Zairean tin had an output of 2,603 tons of cassiterite compared to 2,635 tons in 1981. Zaire-tain which is the number two producer saw its output fall by 20 percent from 591.5 tons of cassiterite to 471 tons in 1982. Société Minière de Goma (80 percent French owned) increased its cassiterite output from 65.5 tons in 1981 to 70.4 tons in 1982.

Sominki also showed a fall in production for other metals, 74 tons of wolframite in 1982 compared to 89 tons in 1981; 41 tons of columbotantalite in 1982 compared to 44 tons in 1981; 31 tons of monazite in 1982 compared to 35 tons in 1981; and finally this company maintained its production of lead vanadate at 420 tons.

Gecamines and the Ciment Lac company both saw a fall in their coal production. In total 123,683 tons of coal were produced in Zaire in 1982 compared to 129,391 tons in 1981.

One of the main problems of the Zairean mining industry remains the difficulty of transporting and exporting mineral products. Since Zaire only has a short Atlantic coastline, about 60 kilometers, much of its output is exported through neighboring countries. Some 10 percent of the copper production and 30 percent of the zinc production are exported through Dar-es-Salaam. This route involves shipment of the metal across Lake Tanganyika the Tanzanian railhead.

Some 25 percent of the copper output and 20 percent of zinc are railed to the port of East London in South Africa. About 15 percent of the copper production and half of the cobalt production are railed to Durban in South Africa. All these exports must use the railroad systems of Zambia, Zimbabwe, and South Africa. Another 20 percent of zinc production was formerly railed to the Angolan port of Lobito but this link has been cut for some time now. Finally, a large proportion of the cobalt production is also air freighted out of the country.

The situation is further aggravated by the lack of transport infrastructure within Zaire itself. Thus various factors have contributed to reduce the movement of mineral products to the national port of Matadi at the mouth of the Zaire river. These include a blockage in the shipping channel at Matadi, drought in the upper Zaire region towards the end of 1982, and inefficiency of the Office National des Transports (Onatra) in moving shipments at Ileho. In addition there has been a persistent shortage of rail cars to move cargo from Zaire to the south in general and South Africa in particular.

Some 50 percent of the copper and 30 percent of the zinc output are shipped to Matadi where the Compagnie Maritime Zairoise (CMZ) handles 40 percent of the exports, the Compagnie Maritime Belge (CMB) 20 percent, and the remaining 40 percent are carried in vessels of other lines.

For 1983 Sozacom foresees a production of 514,000 tons of copper, that is an average monthly production of 42,800 tons. The average monthly production for 1982 was 41,900 tons and in 1981 was 42,000 tons. Since 1976 Zaire has only exceeded the 500,000 ton copper production level in 1981 (503,400 tons) and in 1982 (502,900 tons).

ZAMBIA

As it has been for many years, the story of the Zambian mining industry is one of continuing problems, battling against weak metal markets, shortages of foreign exchange for spare parts and new equipment, and shortages of fully trained operating personnel.

At the end of December 1982, Zambia Consolidated Copper Mines Ltd. (ZCCM) reported a loss for the nine months to that date of nearly $130,000,000, compared with a loss of some $76,000,000 in the same period of 1981. Production for the nine months totalled 424,358 metric tons of copper and sales amounted to 464,346 tons.

The company suffered an unexpected blow in the third quarter when there was a serious fire at the Nkana power plant in Kitwe during November. This caused protracted closures of a number of plants including the smelter and acid plants. Thus there was a pass along affect caused by a shortage of acid which temporarily closed the leach plant operations at Nchanga and Kalulushi. The acid shortages also affected the production of cobalt.

Cobalt production for the whole year of 1982 was almost maintained at 2,250 tons, the level of the previous year. There were a number of positive developments in this area, such as the commissioning of the new Nkana cobalt refinery, despite the fact that 1982 was probably the worst year on record for the metal. The producers were forced to bring their official price down to $12.50 per pound in February 1982 and in November, the free market price slumped to an astonishingly low $3.75 per pound.

The Nkana roast, leach, and electrowinning (RLE) plant was succesfully commissioned and should produce 2,500 tons of cobalt this year, provided there is sufficient demand. It brings ZCCM's total production capacity up to around 5,000 tons per year. Another development during the year was the commissioning of the cobalt vacuum refining plant at Chibuluma Division. The purpose of the plant is to increase the purity of the finished cobalt.

Work began during the year on the Tailings Leach Plant Stage 3 (TLP3) of Nchanga Division in Chingola. The plant is to produce more than 520,000 tons of copper from stockpiled tailings over a life of 15 years. TLP3 is scheduled to be commissioned in December 1984. It is estimated that TLP3 will produce copper at less than $1,040 per ton, thus producing some of the cheapest new copper in the world. It will be capable of treating 1,500,000 tons of tailings per month, 850,000 tons from stockpiles and 650,000 tons from current mine operations. It will require about 360,000 tons of strong sulphuric acid, available from existing Zambian sources, and over 200,000 tons of quicklime per year. To supply the latter a new lime burning plant is being added to the Ndola Lime complex.

Zambia was the first recipient of European Economic Community assistance under the new mineral support plan (Sysmin) attached to the Lomé II Convention. The EEC agreed a soft loan of about $60,000,000 to ZCCM to help finance a series of projects aimed at improving production and productivity. ZCCM aims to increase production by 19,000 annual tons and reduce costs by over $3,000,000. Equipment is to be replaced at Nkana, Nchanga, Chambishi, and Mufulira Divisions.

In connection with the plans for improved productivity and production, ZCCM appointed a group of mining engineers and financial advisers to examine its operations. Investigations will include sources and prices of machinery, equipment, and spares; management consultancy agreements; underground blasting and services sub-contracting practices, ore, concentrate, and finished product transport; manpower contracts; inventories, including dead stock; control of gold and silver production at Kabwe and Ndola; and scrutiny of feasibility studies of major current and future capital projects.

During the year, Nchanga Division became one of the growing number of users of trolley assisted truck haulage, at its open pit in Chingola. The system, worth some $4,600,000 was installed by General Electric and is expected to save about a quarter of the Division's annual imports of Diesel fuel, currently valued at about $18,200,000.

The Geological Survey Department (GSD) is involved in an extensive exploration program around the country. Test drilling for iron ore has started at Nambala, 150 kilometers (93 miles) northwest of Lusaka. Other iron ore exploration is scheduled for Pemba, 170 kilometers (106 miles) to the south, and Kasempa, 350 kilometers (218 miles) northwest of Lusaka. The intention is to assess the quality of Zambian ore for small-scale steel manufacturing. In this connection, Tata Zambia Ltd. completed feasibility studies for a proposed $77,000,000 steel mill, after the abandonment of the 250,000-ton-a-year Tika steel mill plan.

In conjunction with the French government, the GSD is carrying out the East-of-Lusaka project. This will map a belt stretching from Lusaka to Chipata, on the

eastern border with Malawi, to investigate mineral occurrences. An agreement has also been reached with Bureau de Recherches Géologique et Minières (BRGM) for further work.

Diamond exploration is being undertaken. Work in the Dongwe area, where De Beers is active, has revealed the possible presence of kimberlite pipes.

The Reserved Minerals Corporation continued with its efforts to control emerald mining. It mined 66,000 grams (2,112 ounces) of emeralds last year and made sales in Europe, Asia, and the United States. It has also signed an agreement with the International Development and Construction Company (Idco), of Saudi Arabia, whereby Idco will take a 49 percent share in companies formed to mine and market emeralds and other precious stones. Idco's president, Prince Mansour, visited Zambia in October and the joint venture has started recruiting staff to prospect for and mine emeralds.

ZIMBABWE

Despite the continued slump in gold markets during the first half of the year exploration and development in the gold mining sector continued. Total gold mine production increased to 13,000 kilograms (400,000 ounces) as two new mines came into production. Rio Tinto Mining (Zimbabwe) Ltd.'s Renco mine was operating at full capacity by the end of the year. The mine is to produce about 1,500 kilograms (48,225 ounces) of gold per year and its life is expected to be 20 years. The ore also contains significant copper and is being treated by the carbon-in-pulp process. Reserves of 1,000,000 metric tons of ore had been proved down to the 200-meter (656-foot) level and exploration was continuing.

The company's Brompton mine is likely to be expanded this year, combined production of the Brompton and Patchway mines was around 45 kilograms (1,500 ounces) per month. Rio Tinto is also investigating a small gold mine in the Gatooma area.

At year-end, after much speculation and attempts to save the mine with government loans, Rio Tinto's Empress nickel mine was placed on a care and maintenance basis. It had operated at a loss throughout the year. The nickel refinery at Eiffel Flats continued to operate at full capacity, supplied with matte by BCL Ltd. from its Selebi Pikwe operation in Botswana. However, it was unclear what would happen in May this year when the contract with BCL expired; no other matte supplies had been arranged at the end of 1982. Overall, Rio Tinto suffered an operating loss of $10,700,000 compared with a profit during 1981 of $1,240,000.

Union Carbide was also still very active in the gold sector. Sinking of an exploration shaft was commenced at the Reroro prospect in the area of the Lonely mine near Bulawayo. The company also increased exploration activity in the Midlands and took out a new Exclusive Prospecting Order (EPO) in the Shabani area.

Lonrho brought the Tiger Reef mine back into production. It is milling about 6,000 tons a month to produce 18 kilograms (580 ounces) of gold from low-grade ore. Work also continued on the reopening of the Legion mine, which should mill about 3,000 tons a month to produce the same amount of gold as Tiger Reef. At other mines in the group, milling capacity was increased at the Shamva (WORLD MINING, May 1981, pages 60 and 61) and How mines.

In the first quarter of 1983 results from Cluff Mineral Exploration Zimbabwe's (CMEZ) exploration program had defined five gold and three base metal occurrences in the southwest of the country. Sampling at the Seventh Trial prospect has shown values of almost 7 grams (0.22 ounce) of gold per ton. Grades averaging 6.2 grams (0.2 ounce) of gold per ton have been indicated on the Royal Family property. The Rosalind East massive sulphide zone showed values up to 3.8 and 1.3 grams (0.12 and 0.04 ounce) per ton in the massive and disseminated zones, respectively. Intermittent gold mineralization was found at the Kotze's Luck-West Barton prospect.

CMEZ will begin work during the middle of this year at the Nita gold prospect. Interest in the prospect stems from reports dating back to 1911 stating values of 10 grams (0.32 ounce) gold over 9.1 meters (30 feet) within a development cross cut at 25 meters (82 feet).

The first of the base metal prospects is the Block EG occurrence which overlies 1,700 meters (5,580 feet) of outcropping gossan exhibiting anomalous copper-zinc values. Lead, copper, and zinc mineralization was found at the Broken Boulder prospect and stratabound disseminated stibnite in sedimentary formation was identified at the Crocodile antimony prospect.

Although prospecting in general was booming, with more than 5,000 licences issued during 1981, compared with 1,000 in 1979, the recession did hit the mining industry severely. At mid-year a total of 177 mines in the country, a country in which small mines form the backbone of the mining industry, had been closed; 163 small gold mines, employing 1,880 workers, and 14 base metal operations, employing 120 people.

MTD (Mangula) Ltd., the largest copper producer in Zimbabwe, also suffered serious problems during 1982 and had to be loaned well over $9,000,000 by the government, losses amounted to more than $10,000,000. Operations will be maintained at the Mangula mine, the biggest loss maker. The company applied for permission to close the Shackleton mine of Lomagundi Smelting and Mining, but government insisted that operations continue and further loans were negotiated.

Two other companies had to apply for loans, Bindura Nickel, the largest nickel producer, and Zimbabwe Alloys, the second largest chrome producer.

During the year the government established the Minerals Marketing Corporation (MMC), despite objections from the mining companies. This organization now supervises the sale of all mining products.

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AFGHANISTAN

The Soviet Union will undertake copper mining at the Ainak deposit in Logar, according to the Peshawar-based Association for Information and Documentation, a news agency formed by Afghan exiles. For this purpose, the Russians intend to construct a road link of 17 kilometers (11 miles) between Logar and Ainak. Mining will be developed by Russian engineers and Afghan workers. In the last Yearbook report to come out of Afghanistan (WORLD MINING, Catalog, Survey, & Directory Number 1979, page 229) it was reported that the Ainak deposit is world class and that during 1978 an intensive program of exploration was continuing with a view to developing and mining this large, high-grade deposit as soon as possible.

Similarly, it is reported that construction work has started on a copper smelter located in the vicinity of the Soviet embassy in Kabul. It is further reported that houses located adjacent to the construction site are being evacuated in order to build residential accommodation for the smelter staff.

It is thought that following the takeover of natural gas resources, the Soviet Union now intends to exploit Afghanistan's mineral resources. Following the action at Ainak, it is thought that the Soviets will now move in on the precious stone mining areas of Gandamak, Karakar, Jorm, and Koron-u-Munjab. Afghanistan was noted for its onyx marble and lapis lazuli and, again in the last Yearbook report from the country, planned production of these for 1980 was reported to be 10,000 and 7 metric tons, respectively.

BAHRAIN

The Arab Iron and Steel Co. (Aisco) was formerly established during 1981, its financing including a 12.5 percent share held by the Arab Mining Company (Armico). The plant should be producing by 1984, at a cost of some $330,000,000, using imported ores to produce some 4,000,000 metric tons of 67 to 68-percent Fe pellets each year for sale among the Gulf states. Three direct reduction plants are being developed in the area; one in Saudi Arabia with a capacity of 800,000 tons a year, requiring 1,200,000 tons of pellets; one in Iraq to produce 1,485,000 tons, requiring 2,200,000 tons of pellets a year; and one in Qatar producing 400,000 tons, requiring 600,000 tons of pellets per year. All the plants are scheduled for production in the mid-1980's.

Aluminium Bahrain (Alba) continues to operate, at 170,000 tons a year. Construction of Gulf Aluminium Rolling Mill Company's (Garmco) facility continues. Both companies have expressed support for the Gulf Organization for Industrial Consulting's proposal to set up a 2,000,000-ton a year alumina refinery on the Arabian Gulf.

BURMA

The No.2 Mining Corporation is undertaking extensive work on the alluvial tin deposits of Tenasserim Division in the south. Prior to World War Two, this area was the largest producer of tin and tungsten in the country. Some 350 locations are known to have potential but most have yet to be fully explored and evaluated. The Corporation plans to develop five new gravel pump mining operations at Ahtwin Bokypin, Zadiwin, Kyaukmedaung/Onzin, Santhe, Chaung, and Thithladaw. The aim is to increase annual tin concentrate production by 650 metric tons, a rise of about 63 percent over the current output of about 1,030 tons.

Total financing will be $30,000,000, the foreign exchange component of which, $16,000,000, will be loaned by the Asian Development Bank. Aside from the new mines, other components of the project include; a foundry for gravel pump parts, a central beneficiation plant, a central maintenance workshop, and exploration equipment. The full project is expected to be completed by late 1985.

CHINA

The year 1982 was not a year of major developments and large new mining projects in China. There was, however, a continuing program of modernization, mechanization, and technical improvement at many metal mines. The coal industry had a higher priority for development and to increase production than did the metals industries, so new mines were under development, preparation plants were under construction, and major plans were being made to increase coal production from 680,000,000 annual tons in 1982 to 770,000,000 tons by 1985 and 1,200,000,000 tons by 2000.

The era of sudden and large planned projects, such as the Dexing porphyry copper and the Baoshan steel mill, appears to have come to an end.

China continued with its major program of sending engineers overseas for observation and training, and welcomed mining engineers and equipment salesmen to visit Chinese mining centers. The continuing result of this technological exchange program is most important and is already resulting in some increases in production as well as more efficient production.

There was increased emphasis on foreign sales of metals and minerals, and a more coordinated program for such sales. In the past different provinces and the national exporting company were all vying to make sales of the same product.

China has large reserves of metal and refractory grade bauxite in Yunnan, Guangxi, Henan, Fujian, Hebei, Sichuan, and Liaoning provinces. There has been a steady increase in production of aluminum and further increases are planned; 10 smelters have an installed annual capacity of 386,000 tons, and two additional major smelters are planned.

With the high cost of energy in Japan, several alumina plants and aluminum smelters there have been closed. China was interested in buying these plants and moving them to Shanxi province (its largest coal producing province) to use cheap coal-generated electricity. Over 800,000 tons of alumina and 400,000 tons of aluminum would be produced from these planned plants.

Work resumed on construction of the Baoshan Iron and Steel plant just north of Shanghai. First hot metal is scheduled for production in 1983. The mill can use imported or local ore, but while China has many deposits of iron ore, most are small and low grade. Mine and benefi-

Chinese production of metals and minerals in tons

Commodity	1980	1981	1982
Gold[1]	300,000	600,000	800,000
Silver[1]	1,700,000	2,100,000	2,400,000
Copper[2]	200,000	225,000	235,000
Lead[2]	155,000	155,000	165,000
Zinc[2]	150,000	155,000	160,000
Coal	668,000,00	650,000,000	680,000,000
Iron ore	88,000,000	100,000,000	108,000,000
Aluminum	375,000	360,000	380,000
Tungsten	12,000	16,000	21,000
Bauxite, refractory	70,000	80,000	80,000
Bauxite	1,500,000	1,600,000	1,600,000
Tin	16,500	15,000	16,000
Fluorspar	390,000	400,000	450,000
Titanium, sponge	1,800	1,800	1,800
Pig iron	41,500,000	39,000,000	40,000,000
Steel	41,000,000	39,200,000	40,000,000
Antimony	10,000	9,000	8,000
Mercury[3]	20,000	18,000	18,000
Nickel	10,000	11,000	12,000
Molybdenum	500	600	600

1. Ounces. 2. Mine production equivalent. 3. 76-pound flasks.

ciation plants were expanded at the Anshan Iron and Steel complex—China's largest steel center. Steel capacity is being expanded to an annual output of 7,000,000 tons of pig iron.

China has major deposits of ferroalloy metals: tungsten (the world's largest known reserves), molybdenum, nickel, and cobalt. Tungsten production has averaged about 15,000 tons of 65 percent WO_3 concentrate for several years. A new molybdenum mine is being developed at a skarn deposit, with proven reserves of 40,000,000 tons of 0.23 percent Mo in Liaoning province.

The large Jinchuan nickel deposit in Gansu province, which is mined by open pit and underground methods, is being expanded. A smelter and electrolytic refinery have been operating here for almost 20 years. Nickel is also recovered at 17 other smelters and refineries. Most of these are primary copper smelters with nickel as a byproduct. However, a new nickel recovery plant is scheduled for operation in Jilin province in 1983.

China produces about 15,000 tons of tin per year from both placer and lode deposits in Yunnan and Guangxi provinces. The center of production has long been at Gejiu in southern Yunnan. Another major production center is at Dachang in Guangxi. Major exploration programs to the east in Guangdong province reportedly found tin-bearing veins. This Chinese tin belt is the northern extension of the great Asian tin belt extending from Indonesia northward.

The Bayan Obo iron ore mine in Nei Monggol contains a high percentage of rare earths. A concentrate of these metals is recovered at the Batou steel plant while the iron concentrate is fed to the blast furnace. The rare earth concentrate is recovered for the China Rare Earth Company, which has been seeking foreign assistance in building plants to convert the rare earths into mischmetal, cobalt-rare earth magnets, and other products.

The China National Metals and Minerals Import and Export Corporation launched a major international drive to sell high-purity lanthanum, cerium, yttrium, and europium oxides from Bayon Obo concentrates.

Dexing, the largest copper mine in China and one of the world's major porphyry coppers, has increased copper ore milling rate by 5,000 tons per day and a new 15,000-ton per day line is being planned. Copper output has increased at an annual rate of 18 percent.

Dexing is the largest of a group of five ore bodies and is the most northerly. To the south and west four mines will be developed. The most important of these is Yongping, which is being developed for a 1984 start.

The new Guixi 100,000-ton per year flash copper smelter, using the Outokumpu Oy smelting technique, and being built by Sumitomo Metal Mining Company, should be operating in 1983. Dexing concentrate will be the largest source of feed.

A new lead and zinc mine is being developed in Quinghai province and is scheduled to be in production in 1986. The new mill under construction will have a designed capacity of 1,000,000 tons per year and combined lead and zinc production, in concentrates, is 60,000 tons per year.

China has placed great emphasis on increasing production of gold and silver. The largest gold mines are in northern Shandong province, where auriferous quartz veins in granite are mined. The central government operates the five largest mines; about 25 smaller mines are operated by local groups. Studies continued on the expansion and modernization of the five largest mines.

Three new dredges are operating in Heilongjiang province, and a fourth dredge is being built.

DUBAI

Increased production, reduced operating costs, and an improved program for training nationals were the highlights of 1982 for the Dubai Aluminium Company Ltd. (Dubal). The smelter produced 148,739 metric tons of aluminum, a significant bonus over planned capacity of 135,000 tons per year. Steps are being taken to increase production of extrusion billet, a premium product. Production of billet in 1982 had been planned at 9,000 tons, whereas 28,000 tons were actually produced.

All the metal produced was sold. Dubal has now supplied aluminum to customers in 16 countries. Five new markets were opened up during 1982; Australia, New Zealand, Turkey, Thailand, and The Netherlands. In December, over 1,000 tons of billet were sold to the United States, which could become another important market for Dubal.

INDIA

The first phase of the Malanjkhand copper mining and concentrating operation was commissioned in May 1982. The second phase will commence between 1983 and 1984. The Malanjkhand copper deposit is situated in Maihar Tahsil, Balaghat district, Madhya Pradesh. It extends for a strike length of 6 kilometers with ore persisting in depth to over 300 meters. The schedule of production plans for 1,000,000 tons of ore at 1 percent Cu between 1982 and 1983; 1,500,000 tons of ore at 1.4 percent Cu in 1983 to 1984; and from June 1984 onwards 2,000,000 tons of ore at 1.2 Cu annually.

Hindustan Copper Ltd., which owns the project, has engaged Golder Mofitt Associates of the United Kingdom as mining consultants. The concentrate, containing about 24 percent Cu, will all be railed to the Khetri smelter, located in Rajasthan.

Further work on the Rampura-Agucha Pb-Zn deposit of Bhilwara district, Rajasthan has shown that this belt contains a minimum of 53,000,000 tons of combined metals (14 percent Zn and 1.5 percent Pb), one of the richest known deposits in the world.

Poland has offered cooperation for exploration for copper, lead, and zinc and in the design and deepening of metalliferous mines and the design and building of processing plants.

The first commercial sponge iron ore plant, Orissa Sponge Iron Ltd., went into production in July 1982. It is a 500-ton per day facility. The plant was installed by Allis-Chalmers. There is also a pilot sponge iron plant at Pallaoncha in Khamman district, Andhra Pradesh with a capacity of 30 tons a day.

Indian production of ores, metals and cement in metric tons

Commodity	1980	1981	1982
Coal	109,102,000	123,104,000	128,225,000
Lignite	4,549,000	5,966,000	8,675,000
Bauxite	1,775,000	1,922,593	1,853,751
Chromite	320,622	336,095	339,196
Gold[1]	2,637	2,495	2,238
Iron ore	40,925,429	41,254,000	40,902,000
Lead concentrate	16,616	20,017	21,747
Manganese ore	1,666,467	1,525,559	1,448,134
Silver[1]	11,381	17,298	14,404
Tungsten concentrate[1]	94,107	38,831	53,529
Zinc concentrate	46,294	52,876	52,839
Apatite and phosphorite	542,907	567,611	559,986
Asbestos	32,468	24,515	26,761
Barites	434,015	399,013	325,368
Diamonds[2]	14,432	14,542	12,913
Dolomite	2,017,543	2,071,580	2,132,814
Fluorite concentrate and graded	21,207	22,905	24,902
Graphite (r.o.m.)	54,786	59,021	52,376
Gypsum	867,896	943,663	970,165
Kaolin	452,219	508,886	531,089
Kyanite	48,740	38,868	33,951
Limestone	29,211,296	31,848,000	33,462,000
Magnesite	395,104	463,118	407,071
Mica, crude	7,930	8,375	8,584
Pyrite	82,905	57,598	55,853
Sillimanite	14,488	12,335	13,066
Talc and steatite	331,647	341,316	300,338
Wollastonite	5,790	15,915	20,272
Steel ingots	9,358,000	10,616,000	10,628,000
Ferroboron[1]	460	—	—
Ferrochrome	16,494	31,333	40,244
Ferromanganese	158,308	208,836	150,707
Ferromolybdenum[1]	121,829	158,683	116,928
Ferrosilicon	54,319	60,253	36,060
Ferrotitanium[1]	321,233	170,107	86,459
Ferrotungsten[1]	21,206	12,167	3,269
Ferrovanadium[1]	92,262	117,905	86,459
Silico chrome	4,050	4,339	4,468
Aluminum	184,838	212,844	216,679
Copper (electrolytic)	17,021	14,787	15,066
Lead	14,846	25,406	23,193
Zinc	43,627	57,434	52,571
Cement	17,902,000	20,870,000	22,091,000

1. Kilograms. 2. Carats. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

The establishment of an integrated aluminum plant on the east coast with French assistance was progressing as scheduled. Work on the alumina plant at Dhamanjoli in Koraput district and the smelter at Angul in Dhenkanal district progressed well. The project will go into production in 1985.

IRAQ

Until recently, apart from hydrocarbons, sulphur from the Frasch mine at Mishrag was Iraq's only significant mineral product, with an annual output of about 600,000 metric tons. Now however a major fertilizer complex has been set up at Al Quaim to produce 1,100,000 annual tons of fertilizer using sulphuric acid produced with sulphur from Mishrag and phosphate rock from Akashat.

The Akashat mine came into production in 1981. It comprises two open pit mines, each supplying half of the production. The Akashat deposits are situated in the western desert of Iraq; after about 15 years, mining at Akashat will move to other deposits nearby.

Total reserves in the area are estimated to be 400,000,000 tons, guaranteeing the complex a long life, whatever the production level. Current production is at a rate of 3,400,000 tons a year. However, provision has been made to double this level, if justified, with little extra investment by moving from 12 to 24-hour operation.

IRAN

It was reported in August 1982 that the Sar Chesmeh copper mine had produced 4,000 metric tons of copper since its concentrator was commissioned in December 1981 and its smelter came online in May last year. This represents just 2.8 percent of its planned capacity of 145,000 tons a year. A total of 2,480,000 tons of ore were said to have been extracted from the mine itself, between December 1981 and August 1982. The concentrator production was 46,507 tons of concentrate and 17,428 tons of lime. The mine's managing director reported last year that Sar Chesmeh's proven reserves amounted to 450,000,000 tons of ore containing 1.12 percent Cu. Probable reserves total another 800,000,000 tons.

News agency sources last year reported that gold occurrences had been confirmed in two regions in the center of the country between Tehran and Esfahan. Some 750,000 tons of ore have been proved containing 5 grams (0.16 ounce) of gold per ton. Gold has also been confirmed at seven other locations in the area. It was reported that 4,200 kilograms (135,030 ounces) will be produced over the next 10 years.

Two gold mines in Muteh region, Esfahan province, have produced 75,000 tons of gold ore to date and are now planned for expansion. It is reported that there are 130 small mines in the province, mostly operating. Negotiations began last year to set up a central beneficiation plant in the region with a capacity of 400 tons of gold ore per day.

The iron ore industry, centered on the town of Bafq, has intensified exploration and production. Ore mined is reported to have increased by some 35 percent. Over the last 15 years 40 mines of various sizes have been developed in the province of Kerman, where reserves are estimated at 1,000,000,000 tons of potential ore of unspecified grade.

Teheran has once again started talking about the Gol-e-Gohar iron ore deposit, which is located near Sirjan in the southeast of the country. It is now reported that it will be developed to a possible production rate of 13,000,000 tons a year, primarily for the local steel industry.

However, development of this deposit has been much discussed in the past. In 1974 Gränges International Mining was awarded a contract involving planning and development of a 5,000,000-ton per year mine and treatment plant that never materialized. Reserves at Gol-e-Gohar are reported by sources in Iran to be 2,500,000 tons of low-sulphur magnetite, 50,500,000 tons of oxidized low-sulphur magnetite, and 92,000,000 tons of high-sulphur magnetite.

ISRAEL

Despite the world-wide recession and the weak state of the fertilizer market, the total volume of mineral production in 1982 was more or less the same as in 1981.

Negev Phosphates suspended operations at the Oron mine, following last year's decision to close the calcination operation. Production at Arad increased in order to supply the new wet process phosphoric acid plant at Rotem, which reached its rated capacity of 120,000 tons P_2O_5.

The systematic exploration for phosphates continued under the joint sponsorship of industry and the state. A major new field was discovered in the Bekaa Beer Sheva. Initial indications are that it contains about 200,000,000 tons of phosphate of about 28 percent P_2O_5. The richest area contains about 50,000,000 tons of material that averages in excess of 31 percent P_2O_5.

The new Makleff plant of the Dead Sea Works at Sdom also reached its rated capacity during the year. A further expansion is being undertaken, and this will bring the total potash production capacity to 2,200,000 tons per annum.

At the Timna Copper Company the manganese chemical plant was commissioned and the production of feed grade manganese sulphate commenced. The nominal capacity is 10,000 tons per annum.

Intensive efforts are being made to utilize the oil shales of the Negev region. To this end construction was started on a 500-ton per day pilot plant for the combustion of shales from the Rotem area. Start up is scheduled for early 1983.

Israeli production of metals and minerals in metric tons

Commodity	1980	1981	1982
Phosphate rock	1,910,000	1,950,000	1,870,000
Calcined phosphate	490,000	450,000	100,000
Defluorinated phosphate	32,000	37,000	27,000
Potash	1,300,000	1,490,000	1,680,000
Cement	2,000,000	2,000,000	2,000,000
Magnesia (periclase)	32,000	34,000	36,000
Glass sand	60,000	60,000	65,000
Calcined flint clay	17,000	10,000	10,000
Bentonite	10,000	10,000	10,000
Cement copper	—	4,400	3,700

1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

JAPAN

Weakened private consumption and lower levels of housing construction and investment have brought a reduced rate of economic growth to Japan. In addition, the worldwide recession in 1982 resulted in decreased exports. The domestic economy continued to stagnate.

Accordingly, demand for non-ferrous metals, especially copper, lead, and zinc, dropped to the lowest level of the past several years, and prices continued to decline against higher costs throughout the year.

The government's Metallic Mineral Prospecting Agency has been continuing exploration in Japan's mining districts for the past 19 years by means of a three-stage program, involving a broad drilling survey, detailed exploration, and industry prospecting.

In 1982, the agency operated in the same districts as in 1981—worthy of notice are North Kagoshima and Kushikino districts in Kyushu, Kudo district in Hokkaido, and Kiruhara district in Miyagi prefecture.

The agency carried on a broad drilling survey in the Hishikari area of Kushikino district in Kyushu, on a concession of the Sumitomo Metal Mining Company. Gold and silver mineralization confirmed in 1981 was followed by confirmation of a promising silver and gold deposit in 1982.

Sumitomo proceeded with industry prospecting of this area, drilling 18 holes, each showing existence of a deposit. The deposit is 600 meters (2,000 feet) long at a depth between 100 and 150 meters (300 and 500 feet). Reserves are estimated at 1,500,000 metric tons averaging 80.0 grams per ton (2.3 ounces per short ton).

Mitsui Smelting and Refining Com-

pany also decided to commence exploration in its mining area in the vicinity of Hishikari gold mine. The company has a program of four drill holes totalling 1,700 meters (5,600 feet).

In the Kudo area of south Hokkaido, the agency discovered gold, lead, and zinc, and silver mineralization. The deposit occurs 1 kilometer (0.6 mile) west of Chugao Mining Company's Jokoku lead-zinc-manganese mine. It was confirmed by drilling at a minus-20° oblique angle to a depth of 420 meters (1,400 feet).

In the Kurihara area of Miyagi prefecture, in the vicinity of Hosokura mine, a detailed exploration was carried out during the past two years; a total of 2,000 meters (7,000 feet) drilling has been completed in three holes, of which one shows a promising lead-zinc deposit. The agency has completed drilling to a depth of 330 meters (1,100 feet), delineating a deposit assaying 1.05 percent lead, 9.4 percent zinc, as well as 0.5 gram gold and 44 grams silver per metric ton (0.01 gold and 1.3 ounces silver per short ton).

Nippon Smelting Company planned to complete expansion of its Saganoseki smelting plant by the end of 1982, increasing production capacity to 300,000 metric tons of copper per year. Refining capacity will also be increased, from 14,000 to 15,000 tons per month.

JORDAN

The Jordan Phosphate Mining Company operating three open pit mines produced 4,353,700 metric tons in 1982; sales amounted to 3,050,946 tons.

Concerning the Shidiya phosphate project, Sofremines was expected to complete the Phase I feasibility study by the end of April 1983, according to the contract signed between the government and Sofremines in January 1982. Further phases will be initiated after satisfactory completion of Phase I.

Gypsum, clay marble and natural sand are mined by the Public Mining Company. In addition, marble, natural sand, aggregates and building stones are mined and produced by small private companies.

The Arab Potash Company (APC) completed its project at a total cost of $466,000,000 in September 1982 (WORLD MINING, December 1982, page 56) and had produced a total of 240,000 tons at the end of the year. This will increase steadily to reach a rate of 1,200,000 tons per year in 1985/86. Marketing contracts have been arranged for all of APC's production for the first 5 years.

Jordanian mineral production in metric tons

Commodity	1980	1981	1982
Phosphate	3,951,000	4,243,653	4,353,700
Clays	25,147	20,786	25,397
Gypsum	65,987	53,054	40,759
Dolomite	343	—	—
Glass sand	416	1,800	—
Marble	8,675	—	400,000
Industrial sand	2,520	—	—
Natural sand[1]	371,519	226,600	1,300,000

1. Cubic meters. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

MALAYSIA

As a result of the continued worldwide economic recession, Malaysia's non-hydrocarbon mining industry suffered a general slowdown in 1982. Exploration and development activities also showed an overall decline. Production and value of virtually all minerals showed significant falls.

The world's largest tin producing country has been experiencing a continual downtrend in production since the late 1970's; this has deteriorated further since 1980. In 1982 the decline in mining activity following the closure of a number of mining units is attributable to the industry's sensitivity to depressed market conditions, steadily declining ore grades, and the rising costs of mining operations.

In terms of value however, tin remained by far the most important nonfuel mineral produced and accounted for 626 of the 648 operating mines in 1982.

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Malaysian production of minerals and ores in metric tons

Commodity	1980	1981	1982
Tin-in-concentrates	61,404	59,938	52,342
Bauxite	920,356	700,866	589,000
Iron ore	371,186	532,455	340,741
Kaolin	46,324	44,084	44,363
Wolfram	68	67	N.A.
Gold[2]	156	180	N.A.
Barite	—	19,365	N.A.
Columbite	33	22	N.A.
Copper-in-concentrate	26,990	27,013	28,642
Ilmenite[2]	189,121	172,757	103,937
Monazite[2]	347	300	N.A.
Zircon[2]	552	1,307	N.A.
Antimony	n.a.	316	N.A.

1. Kilograms. 2. Exports. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.0907 metric ton.

The others were one bauxite, one copper, seven iron ore, and 13 kaolin mines.

The gravel pump sector accounted for 52 percent of tin production; 521 mines produced 27,479 metric tons of tin-in-concentrate. The 43 dredges produced 16,629 tons, 43 open pits produced 2,618 tons, the other 19 mining operations produced 1,644 tons, and 3,972 tons were recovered by other means.

Early in the year the tin price registered a sharp fall, largely a result of substantial releases of tin from the United States' strategic stockpile. This necessitated production cut-backs, and by April export controls were implemented in accordance with the International Tin Agreement. As a result, a number of new tin mining projects had to be shelved and the government imposed a temporary ban on the opening of new tin mines.

However, some new projects were excluded from this ban, because they were already under development before the imposition of export controls. The overall effect has been a decline in the number of mines; falling from 852 in 1980 to 710 in 1981 to 626 in 1982. At the same time a considerable proportion of tin mines, particularly dredging units, had to be put on a care and maintenance basis since their export quotas were insufficient to enable them to meet operating expenses.

Among the new tin mines coming on stream early in 1982 in Perak was the dredge of Timah Dermawan Sdn. Bhd. This unit, equipped with 0.76-cubic meter (27-cubic foot) buckets, is one of Malaysia's largest. The company, a joint venture between the Perak State Economic Development Corporation, Malaysia Mining Corporation (MMC), and Tronoh Mines, is mining a large alluvial tin deposit with an area of approximately 405 hectares (1,000 acres).

Another new dredge was the 0.68-cubic meter (24-cubic foot) "D9S" of Petaling Tin Bhd. (WORLD MINING, July 1982, page 24), which commenced operations mid-year in Selangor. Work was also under way in Johore during the year to reconstruct the 0.24-cubic meter (8.5-cubic foot) "Rasa" dredge of Southern Kinta Consolidated for Syarikat Lombong Sebina Sdn. Bhd., under a joint venture between Johore State Economic Development Corporation and the MMC. This dredge had been dismantled at its former site in Selangor and transported by road to Johore for reassembly to mine a 202-hectare (500-acre) alluvial deposit.

Probably the most significant development during the year was the establishment of Kuala Langat Mining Sdn. Bhd., a joint venture between Kumpulan Perangsang Selangor, the MMC, and Tronoh Mines, to mine the deep alluvial deposit underlying Brooklands Estate in Selangor. A mining plan has been formulated calling for the construction of four large, deep-digging dredges at the rate of one a year. The first unit is expected to be operational during 1983.

Mineral production other than tin accounted for less than 10 percent by revenue of total mineral production. Copper was the only other metal produced on a large scale and showed a favorable trend.

The Mamut Copper Mines in Sabah produced 28,642 tons of copper-in-concentrate. Byproduct production was about 2,250 kilograms (72,337 ounces) of gold and 16,250 kilograms (522,437

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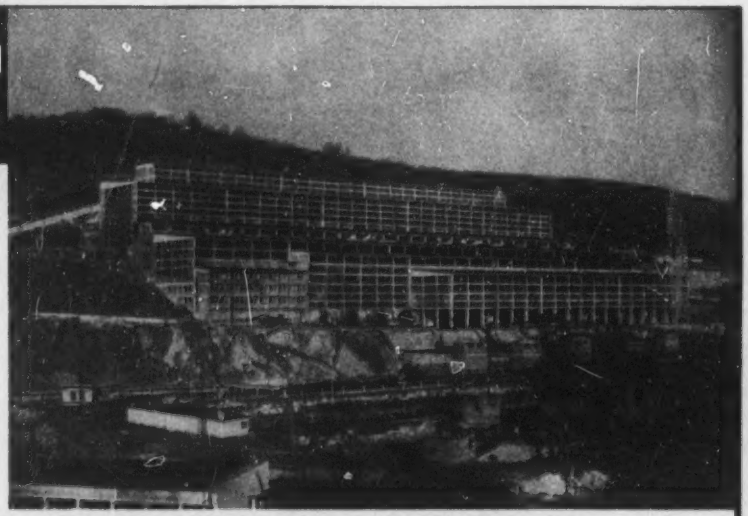

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ounces) of silver. Bauxite was mined in the Pengerang area, Johore. Production continued to decline, falling to 589,000 tons in 1982. The deposit has remaining reserves of about 8,000,000 tons of bauxite.

Kaolin was mined in the states of Perak, Kedah, Penang, Selangor, and Johore. Over half the annual production is consumed locally, the rest is exported. Areas of large reserves are in Bidor (Perak) and Jemaluang (Johore).

The Geological Survey continued exploration projects in various parts of the country. During the year some base and precious metal and uranium geochemical anomalies were identified in the Central Belt area, follow-up work, including diamond drilling, in the Sok area of Kelantan has revealed the existence of promising copper and molybdenum mineralization. Base metal occurrences in Sabah and Sarawak were also followed up.

In Upper Perak two significant geochemical anomalies with potential for primary tin and uranium mineralization have been identified. In Trengannu some areas were revealed to have potential for tin, tungsten, uranium, and iron ore. Quaternary geological studies in selected coastal areas of Pahang have revealed the occurrence of deep-seated placer tin.

The department also conducted a detailed evaluation of coal resources in Sarawak, which has vast potential for bituminous and sub-bituminous reserves, particularly at Silantek.

Very limited exploration activity was undertaken by the private sector. MMC however, carried out detailed follow-up geochemical surveys, ground geophysics, and exploratory drilling in the Sungei Lebir area of Kalantan for gold and base metals. In addition MMC undertook several exploration programs in various states for placer tin, the results of which are still pending. Preliminary prospecting conducted by Kuala Langat Mining in the environs of Brooklands Estate has indicated the presence of tin which is probably an extension of the known deposit.

OMAN

Oman Mining Company L.L.C.'s Sohar project came into production in January 1983. The fully integrated copper project includes mining of three separate ore bodies, a concentrator, smelter, and refinery. The three ore bodies, Lasail, Aarja, and Bayda, contain total proven reserves of 12,000,000 metric tons at a grade of 2 percent Cu. At full production, the Lasail mine will produce 2,500 tons of ore daily and the Bayda mine, 1,000 tons a day. The Aarja ore body will be developed for production as Bayda becomes depleted.

The concentrator will process 3,000 tons of ore daily to produce 250 tons of 24-percent copper concentrate. Annual production of cathode copper, with a purity of 99.97 percent, will be between 16,000 and 20,000 tons.

A specially commissioned investigation has identified six fields of mineral development potential; asbestos, ceramic clays, marble, aggregates, cement, and gypsum.

During the year Hunting Geology and Geophysics completed a survey for Japan Petroleum Development Company (Oman) Ltd. The work included the preparation of photomosaics and an aeromagnetic survey totalling 6,200 line kilometers (3,850 miles). These surveys form an integral part of JPD's exploration program in the Sultanate.

An aluminum extrusion plant is to be built in the Rusayl industrial area to meet Oman's total consumption of extrusions, estimated at around 2,900 tons annually. The plant is to be in production by 1984, using 50-percent capacity. Eventually the plant will produce 6,000 tons per year. Ambitious development plans underway indicate that the consumption of extrusions will increase substantially.

PAKISTAN

An investment of $14,330,000 in mineral developments during the 1981-82 fiscal year showed a sharp increase of 153 percent over last year's revised estimate of $5,660,000. Private investment during 1981-82 was $6,000,000.

Pakistan's mineral wealth is underexploited due to inadequate geological mapping, inadequate infrastructure, a lack of credit facility, non-existence of risk capital, and shortage of skilled manpower. To develop the sector, the government has decided to grant tax holidays and tax concessions to companies engaged in exploration and mining.

Pakistan production of ores and minerals in metric tons

Commodity	1980 to 81	1981 to 82
Chromite	1,108	3,028
Gypsum	554,000	303,000
Limestone	3,464,000	3,682,000
Magnesite	397	1,688
Rock Salt	514,000	534,000
Marble	114,000	95,000
Silica sand	84,000	99,000
Coal	1,597,000	1,765,000
Barite	21,188	26,637
Feldspar	11,071	9,215
Sulphur	403	650
Ochers	267	N.A.
Fire clay	60,485	68,197
Antimony	39	51
Fullers earth	21,285	15,302
Bentonite	893	836
Cement	57,000	110,000
Bauxite	1,754	2,755
Dolomite	24,244	93,488
China clay	40,022	41,279
Manganese	84	80

Source: Statistical Division, Government of Pakistan, Karachi.

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The Resource Development Corporation (RDC) was allocated $3,750,000 during 1981-82 as against $800,000 during 1980-81. A Quebec-based group of three companies; SNC International (Canada), Cofral RTB-BOR (Yugoslavia) and Emmissa (France); has offered to take 25 percent share in the equity of the Saindak copper project in the Chagai district, Baluchistan, and provide the entire foreign exchange requirements, now well over $250,000,000, out of a total $400,000,000 needed for the project.

The group, calling itself the Saindak Joint Venture (SJV), has also agreed to participate in Phase I of the project in collaboration with RDC. Phase I is expected to take one year to complete and require $8,000,000. It comprises a feasibility study of the engineering of the project and preparatory arrangements for the equipment purchasing plan. The second and the final phases will result in the development of the 412,000,000-ton Saindak deposit, where the ore averages 0.37 percent Cu.

Under an exploration and evaluation project for which UNDP has committed financial assistance worth $826,000 the Geological Survey of Pakistan (GSP) continued its search for such mineral resources as chromite, manganese, sulphur, zinc, lead and barite in Punjab, Baluchistan and the North West Frontier Province (NWFP).

GSP has found a potassium-silicate copper porphyry deposit at Koh-i-Dalil in the Chagai district, Baluchistan. Twenty turquoise-quartz veins were identified within a 4-square kilometer (1.5-square mile) area at Koh-i-Dalil. Chemical analyses of the samples are being done. During the year, GSP dicovered lead-zinc-barite mineralization in the Gunga Valley of the Khuzdar district, Baluchistan. Detailed gravity, magnetic and electromagnetic observations were made in the prospect area. Lead and zinc reserves of 6,000,000 tons have been confirmed, besides barite deposits estimated at 5,000,000 tons.

In Upper Sind, a copper deposit was discovered near Ranikot, 195 miles (310 kilometers) north-east of Karachi, in the Khairpur district. Japanese and Yugoslav cooperation in evaluating the find is being sought.

The Pakistan Atomic Energy Commission (PAEC) in late 1982 invited tenders for the construction of a new 937 megawatt nuclear power plant, to be located at Chashma, 20 miles (30 kilometers) south of Mianwali, Punjab. One of the main conditions on the tender is that bidders should supply fuel for the first 5 years and enter into a contract for another 15 years for the supply of components and material, including uranium.

PAEC is also asking for enrichment facilities for locally available uranium that it has exclusively been mining in many parts of the country since the early 1970's; especially at Dera Ghazi Khan, in Punjab, where reserves are estimated at 5,000 tons. During the year, uranium deposits were discovered at Sherani near Dera Ismail Khan, North West Frontier Province (NWFP).

Pakistan's northern areas are regarded as the cradle of precious stones. Gemstone Corporation of Pakistan (GCP) exported gemstones worth $8,000,000 during the year. These included emerald, ruby, spinel, paragassite, aquamarine, topaz, kunzite, garnet and quartz.

During the July 1981 to March 1982 period, 16,196 carats of emeralds were extracted from the Swat mines and the Charbagh-Alpurai project, also in Swat; 3,973 carats of rough ruby from Hunza; 9,447 carats of rough topaz from Katlang (Mardan); 18,405 carats of aquamarine, 66,250 carats of black tourmaline and 5,895 carats of white topaz from Dassu (Skardu).

GCP plans to conduct a feasibility study for further development of the existing emerald mines in Swat. The corporation is presently mining different kinds of precious stones at six places in a 40-mile (60-kilometer) belt in Swat. During the year, GCP found three emerald deposits at Charbagh-Alpurai, Makad and Gujar Killi, all in Swat.

The corporation intends to develop

For more information, Circle No. 368

the Gujar Killi deposit by an open pit mine and carry out exploration evaluation at Charbagh-Alpurai. Aquamarine and beryl deposits at Dassu (Skardu) and topaz deposits at Katlang (Mardan) will also be reassessed.

The Pakistan Mineral Development Corporation (PMDC) has agreed to help the Azad Kashmir Mineral & Industrial Development Corporation carry out further exploration for ruby occurrences found at an altitude of 14,000 feet (4,000 meters) in the Neelam Valley.

As a result of detailed geological investigations, 500,000 tons of low grade chromite reserves have been proved by PMDC in its leases in the Malakand Agency, NWFP. The Pakistan Council of Scientific & Industrial Research (PCSIR) has completed benefication studies on pilot plant scale and succeeded in upgrading the ore up to 45 percent CrO.

A $6,250,000 scheme, now underway, aims to establish mineable phosphate rock in Hazara, NWFP, and to assess potential alternative deposits by undertaking field work and benefication studies.

QATAR

The Gulf Organisation for Industrial Consulting is considering the construction of a 2,000,000-metric ton per year alumina refinery on the Arabian Gulf. A pre-feasibility study has already been prepared. There are already two aluminum refineries, one in Bahrain and one in Dubai. If further studies are carried out, they will focus on bauxite sources. India or Australia are likely prospects but there is also talk of an integrated Arab industry with the Az Zabirah bauxite deposit in Saudi Arabia as the raw material source. This deposit is still being evaluated by Riofinex.

SAUDI ARABIA

At the end of April this year, the King paid an official visit to the Madh ahd Dhahab gold prospect, to the northeast of Jeddah. This signified approval that the mine now go into the full development stage. This is seen locally as especially significant as it is felt that the development of this, the country's first mine, was crucial to an acceleration of mine development activity elsewhere in the country. The mine should go into production in 1986, to produce 30,000 kilograms (964,500 ounces) of gold, 90,000 kilograms (2,893,500 ounces) of silver, 8,000 tons of copper, and 27,000 tons of zinc over a life of 10 years. During 1982 Petromin bought out Consolidated Gold Field's share in the operation but Gold Fields Mahd ahd Dhahab was retained under a mangement contract to complete planning of the project.

Exploration development at Al Masane was completed during 1982. Two major ore bodies have been proven with reserves of some 5,000,000 tons at 1.6 percent Cu, 5 percent Zn, 1.3 grams (0.04 ounce) Au and 40 grams (1.3 ounce) Ag per ton in the first discovery, and an additional 3,000,000 tons at 1.3 percent Cu, 13 percent Zn, and 2.5 grams (0.08 ounce) Au and 90 grams (2.9 ounces) Ag per ton. The capital cost to develop a mine has been estimated at about $100,000,000. Once financing has been arranged, Al Masane could be in operation within 30 months, thus becoming Saudi's second metal mine. Other small prospects in the same area, such as the Jabal Guyan gold deposit, could lead to a small mines complex developing at Al Masane.

Development exploration at Jabal Sayid carried out by Boliden and BRGM was completed in 1982. The 1980 reserve figure was 20,000,000 tons at 1.95 percent Cu and 1.5 percent Zn. At current metal prices, this prospect is unlikely to developed at present.

Exploration of the Nuqrah prospect has identified two small deposits of high-grade, gold-silver rich, base metal ores with conservatively estimated reserves of 466,300 tons containing 8.6 grams (0.3 ounces) Au and 433 grams (13.9 ounces) Ag per ton, 1.5 percent Cu, 4.3 percent Pb, and 11.1 percent Zn. The geologic conditions, ore types, and several varied types of alteration in the area, suggest the existence of further deposits.

Exploration of other important prospects such as the Az Zabirah bauxite deposit and phosphate in the Turayf area continues.

Evaluation of the Atlantis II Deep metalliferous mud deposit below the Red Sea by the joint Saudi/Sudanese Red Sea Commission was completed. The deposit contains 2,000,000 tons of zinc, 500,000 tons of copper, 4,000,000 kilograms (128,600,000 ounces) of silver, and 80,000 kilograms (2,572,000 ounces) of gold. Feasibility studies continue but a commercial production of 60,000 tons of zinc, with corresponding amounts of copper, silver, and gold, seems likely.

SOUTH KOREA

Mining activity in 1982 experienced its worst period as a result of the worldwide economic recession and low prices. Estimated production valued about 10 percent less than in 1981.

The famous Korean tungsten suffered from continued price falls and production decreased by 12 percent. Many small tungsten mines ceased operation. Molybdenum also suffered a major price decrease, causing a 23 percent production decline and forcing mines out of operation in the latter half of 1982. In 1981 there had been a shortage of zinc concentrate, in 1982 production increased by 4 percent and this, in turn, increased copper production by 11 percent. However, lead production, also associated with zinc, decreased by 11 percent due to low grades in the large mines and reduced operation of the small mines due to low prices.

South Korean mineral production in metric tons

Commodity	1980	1981	1982
Iron ore	346,000	332,500	347,254
Copper ore	372	453	533
Lead	11,530	13,630	12,167
Zinc	56,790	56,200	58,175
Tungsten	3,451	3,457	3,053
Molybdenum	500	780	602
Gold[1]	1,282	1,346	1,734
Silver[1]	71,301	100,218	100,683

1. Kilograms. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

The only aluminum refinery (1,700 ton per year capacity), Dae Han Aluminum Company, finally ceased its operation in mid-1982 after a long period of running at a loss. On the other hand, Asia Tungsten Company built a 20-ton per year cemented tungsten carbide (CTC) processing plant in a joint venture with Hertel of West Germany. It started test operation in October.

SRI LANKA

The assessment made in the early 1970's of the rock phosphate in the North Central province of the island, evaluated its potential. So far it had only been used as a source of crushed rock phosphate and is mined by the State Mines and Mineral Development Corporation of Sri Lanka. The development of this valuable and rich resource for the production of tri-phosphate and super phosphate fertilizer is still to be realized. If this materializes it is claimed that it will be second only to the Mahaweli Development program of the country.

The National Aquatic Research Agency has shown interest in assessing the submarine mineral resources of the island in joint ventures. In addition, the Geological Survey Department continued searching for nuclear raw material resources as part of its detailed mineral surveys.

In the state sector the Mineral Sands Corporation produced 68,282 tons of ilmenite, 7,212 tons of rutile and 5,789 tons of zircon and 304 tons of monazite, from the Pulmoddai heavy mineral beach sand deposits on the east coast north of the Trincomalee harbor.

The State Gem Corporation earned $17,140,000 from the export of cut and polished precious and semi-precious gem stones. Recently a number of new localities had been proven for gem bearing alluvium and one or two rare occurrences of gems in-situ and residual material such as at Lunugala and Elehara, respectively. The gem mining industry is still largely private and traditional.

TAIWAN

Mining development and mineral production in 1982 was more or less similar to the previous year. The new copper smelter and refinery at the Chinkuashih gold-copper mine of northern Taiwan was operated at full capacity with an annual production of 50,000 metric tons.

Sulphuric acid was produced as an important by-product of the refinery. The old refinery, which had a capacity 10,000 tons, was shut down totally in 1982. Open-pit gold mining of auriferous outcrops in Chinkuashih continued in 1982 because of the high gold price. A considerable amount of placer gold was also recovered from the streams of eastern Taiwan as a byproduct of sand and gravel.

Taiwan production of minerals in metric tons

Commodity	1980	1981	1982
Coal	2,573,530	2,445,782	2,383,579
Gold[1]	413	1,763	2,232
Silver[1]	2,957	6,837	15,679
Copper, electrolytic	19,303	53,230	47,377
Sulphur	8,099	9,849	20,080
Serpentine	—	118,175	119,295
Pyrite	150	20	19
Talc	9,911	24,774	30,661
Asbestos	683	2,217	2,392
Gypsum	8,170	6,039	2,045
Limestone	12,822,025	13,220,570	11,377,577
Marble	2,838,726	3,269,094	3,154,831
Dolomite	488,725	359,405	261,337

1. Kilograms. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

THAILAND

Thailand's mining industry experienced one of its worst slumps in 1982, which led to the closure of 81 mines in various parts of the country. According to the Department of Mineral Resources (DMR), more than 18,000 mine workers lost their jobs. At the end of December 1982, there were only 922 mines operating with 48,776 workers compared with 1,003 mines and 67,406 workers in 1981. The total value of minerals exported in 1982 was $424,000,000 compared with $515,500,000 in 1981.

Despite lower prices and production restriction, tin continued to be the most important mineral mined in Thailand as the royalty collected in 1982 still represented some 89 percent of the total mineral royalties received.

The year 1982 commenced with high tin prices at over $14.8 per kilogram. By the end of February the price plunged from $14.4 to $12.7 per kilogram, the floor price of the International Tin Agreement, without the prospect of any improvement.

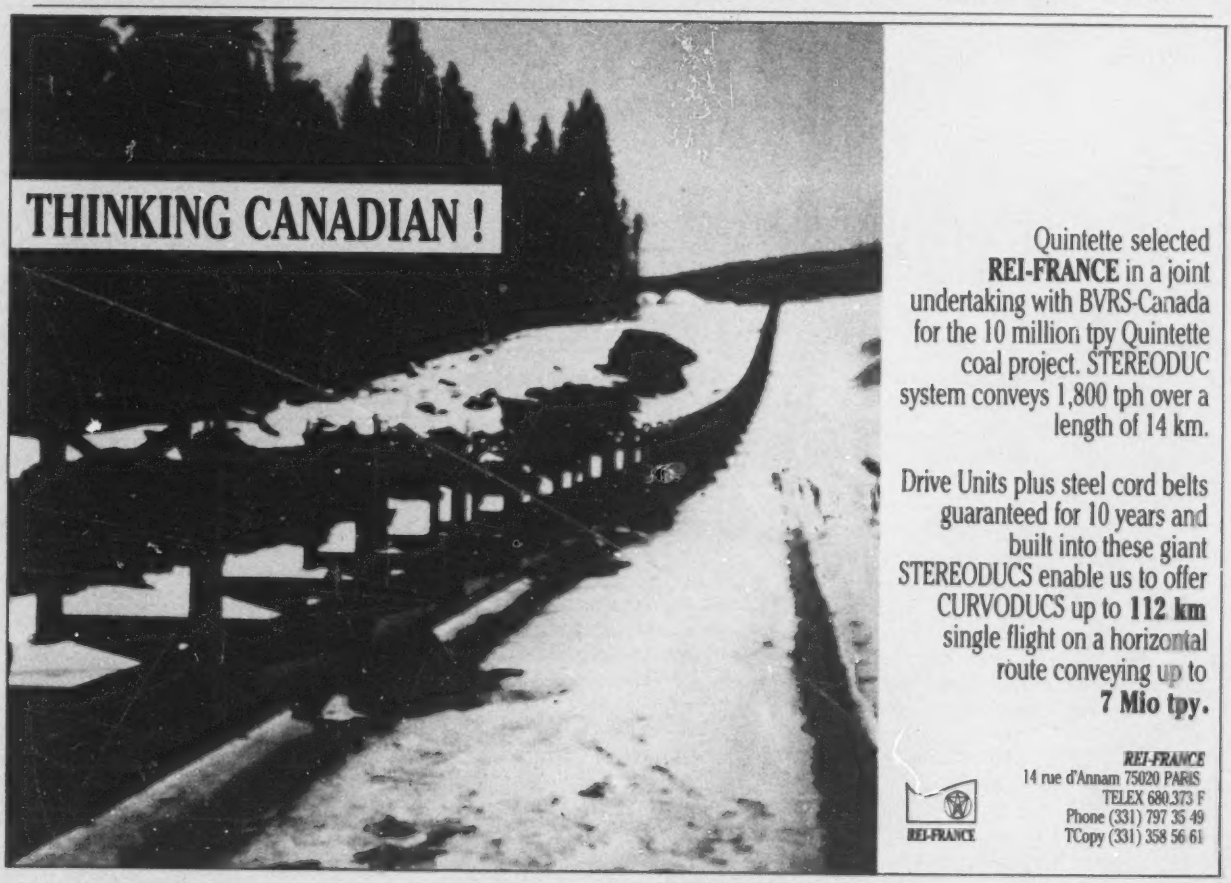
However, the restriction during this period did not affect the production of mines in Thailand as the coastal dredges and suction boats in Panga Province, the output of which is mostly taken by government agencies, were not very active because of the monsoon weather.

Export restriction was increased to 36 percent for the third and fourth quarters of the year. Production quotas were drastically reduced during the fourth quarter when some of the coastal dredges and suction boats in Panga Province resumed operation. Production of cassiterite was reduced from 42,968 tons valued at $420,000,000 in 1981 to 35,644 tons valued at $346,000,000 in 1982.

Other minerals which suffered declines in production and value included tungsten, manganese, and antimony.

Billiton Thailand Ltd., a contractor engaged by the Offshore Mining Organization, continued to operate successfully without interruption by the production restriction imposed by the International Tin Agreement. Tongkah Harbour Ltd. was temporarily closed down for a period of 12 days during the last quarter due to insufficient production quota. Aokam Thai Ltd. reported that its production for 1982 was 12.2 percent below that achieved in the previous year.

The production of lead in 1982 increased 7.5 percent over the 1981 output. The Song Toh mine of Kemco in the province of Kanchanaburi continued to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Thailand production of concentrates, ores, and metals in metric tons

Commodity	1980	1981	1982
Cassiterite	44,986	42,968	35,644
Tin slag	12,356	2,260	2,416
Wolframite	2,661	1,832	1,257
Scheelite	473	516	404
Lead ore	24,847	40,667	43,718
Metallurgical fluorite	172,784	157,311	176,084
Chemical fluorite	60,108	55,181	81,024
Antimony	6,862	2,820	1,567
Manganese ore	54,310	10,917	7,758
Lignite	1,426,566	1,686,044	1,963,764
Barite	305,057	307,046	318,348

1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

play the most important role.

The Padaeng Industry Company commenced the construction of the electrolytic zinc smelter at Tak during the year.

The negotiation between the government and the Thai-American joint venture companies proceeded throughout the year on agreements for exploration and development of the potash deposits in the northeast of the country.

TURKEY

Mining showed a decline in 1982 due to the crisis in the steel industry and poor international trade in general. Mineral exports declined by about 8 percent in value compared with 1981. Trade with the Comecon countries on a countertrade basis has ended, turning normal free trade. This has curtailed trade and reduced mineral production.

The traditional chromite mining of the country suffered a decline. Only high-grade (48-percent) lump ore found suitable customers for export, mostly to the Comecon countries. Sales of concentrate fell to almost nil. Etibank, however, put its emphasis on ferrochrome production, increasing the capacity of the plant at Elazig by a further 100,000 tons a year. This increased exports by 25 percent. A private company, Kromsan, is building a bichromate plant with an annual capacity of 30,000 tons.

Copper production also fell, due to maintenance of the smelter at Samsun and the mine and concentrator at Murgul. The Black Sea Copper Company

Turkish mineral production in metric tons

Commodity	1980	1981[1]	1982
Antimony ore	26,180	27,943	35,560
Asbestos	8,883	2,833	23,617
Asphaltite	558,464	559,616	859,433
Barite	128,353	185,555	110,971
Bauxite	546,546	518,367	509,388
Bentonite	N.A.	30,687	N.A.
Boron minerals	1,133,563	1,531,468	1,270,367
Chromite	550,719	574,474	548,273
Clay	139,702	119,813	151,434
Fireclay	32,026	30,449	29,655
Coal, bituminous	6,598,755	7,629,858	7,161,485
Coal, lignite	16,997,916	19,140,465	20,133,003
Copper ore	1,593,094	2,516,892	2,645,990
Copper blister	15,934	N.A.	N.A.
Dolomite	461,085	86,960	130,136
Emery	31,140	44,135	35,164
Flint	10,127	387	N.A.
Fluorite	1,945	1,986	5,997
Graphite	N.A.	N.A.	3,360
Gypsum	72,234	90,470	74,947
Iron ore	2,578,948	2,669,305	2,125,267
Kaolin	60,263	44,795	37,841
Lead	6,188	2,452	2,202
Lead-zinc ore	125,593	170,807	183,105

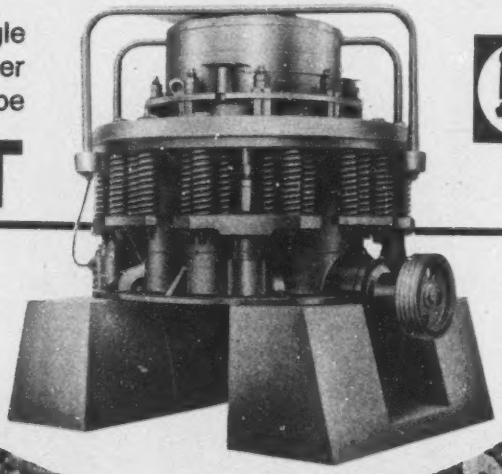
Turkish mineral production (continued)

Commodity	1980	1981[1]	1982
Limestone	564,181	1,050,404	901,212
Magnesite ore	825,876	772,966	930,335
Manganese ore	41,634	14,932	5,525
Meerschaum (boxes)	125	352	211
Marble	5,968	13,686	8,963
Marble pieces	56,662	56,956	N.A.
Mercury (flasks)	4,439	N.A.	79,257
Molybdenum ore	N.A.	7,338	N.A.
Phosphate rock	82,655	103,129	35,400
Perlite ore	25,879	3,650	14,020
Pyrite	77,272	63,690	5,232
Quartzite	N.A.	N.A.	161,504
Salt	1,169,331	1,319,770	N.A.
Siliceous sand	85,694	110,865	850,085
Sodium sulphate	62,635	81,161	124,267
Aluminum sulphate	7,045	9,794	N.A.
Sulphur ore	88,871	118,270	126,444
Tungsten ore	106,319	76,360	170,000
Zinc ore	43,050	55,007	39,214

1. Cubic meters. N.A. Not available. Source Institute of Statistics. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric ton.

Obtuse-angle Cone Crusher Type

DKT



for disintegration of various rocks and minerals. It is manufactured in 5 type-sizes, each in fine, medium and coarse version according to the size of the inlet gap. They are in demand owing to their wide range of applicability, high efficiency and reliability of operation. Crushers with coarse inlet gap serve for disintegration of primarily crushed material to grain of required size or for the precrushing of material which is then treated in crushers with fine inlet gap, i.e. granulators. Granulators serve for the production of final products. They are popular due to excellent properties of the product from the point of view of grain structure and shape.

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has contracted the modernization of these installations to Boliden, working with the Turkish company Tüstaş, at a cost of $25,000,000. The project is being financed by the World Bank. Etibank's new concentrator at Küre, being built with cooperation from Outokumpu, is nearing completion. The major reserves of the Çayeli deposit will be developed by a joint venture of Etibank, Phelps Dodge, and Fenni Gama of Turkey. Exploration drilling continues. Another newly-discovered deposit at Madenköy-Siirt will also be developed. A new road is being built to reach the deposit.

Lead-zinc mining went through a decline in 1982. The Çinkur zinc plant near Kayseri had difficulty obtaining enough ore. However, Etibank is developing the old Balya mine and sinking a new shaft. Production will be 72,000 tons of lead-zinc ore annually.

UNITED ARAB EMIRATES

Chrome mineralization was discovered in the mountain region of Fujairah last year. The prospects, some 350 kilometers (220 miles) east of Abu Dhabi, were found by Geoconsult Company.

There was a drastic change in the laws on precious metals trade in the Emirates last year. Dealers in gold, silver, platinum, and even precious stones will no longer be able to make exorbitant profits under the guise of manufacturing and other charges. Government has taken steps to regularize these activities ensuring a fair deal for merchants and customers alike.

YEMEN

Pilot mining started at the Al-Hamoura copper prospect, in the Haifan area of Taiz province, some 290 kilometers (180 miles) south of Sanna. Bulk samples are being taken for metallurgical testing. The ore body contains copper, nickel, and pyrite, all three in sufficient quantity to be considered for separation as final products. The development is being carried out by Yemen Oil and Minerals Corporation (Yominco) with technical assistance from Geomin of Romania.

Investigation of an old silver mine at Majma, west of Marib, continues. There are as promising lead, zinc, and silver occurrences.

Bureau de Recherches Gèologiques et Minières (BRGM) continues with an exploration program on 15 promising occurences, including copper, lead, silver, and zinc. Core drilling is to be undertaken at some of the prospects.

Members of the Arab Mining Company (Armico) visited the Naham and Hamura prospects where exploration programs are underway on copper and zinc occurrences. Armico has expressed its readiness to provide assistance.

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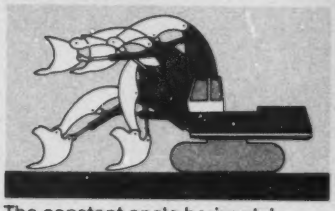

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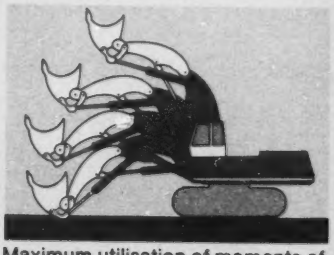

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AUSTRALIA

Gloom in the mineral industry was probably no greater than in most other countries. Although some production increases were recorded, lower metal prices and continued effects of inflation eroded company profits. Exploration and development slowed accordingly.

By Leo A. Lyons
Australasian Editor

WESTERN AUSTRALIA

Commercial alluvial diamond production began at the Upper Smoke Creek of the Argyle deposit on January 1, 1983. An output of about 2,000,000 carats was projected for 1983.

Ashton Joint Venture partners—CRA Ltd. (56.8 percent), Ashton Mining Corporation (38.2 percent), and Northern Mining (5 percent)—signed development agreements in late 1982 and became the Argyle Diamond Mines Joint Venture. DeBeers Central Selling Organization will market all of CRA and Ashton's share of gem quality diamonds and 75 percent of their near-gem quality diamonds. Northern Mining will independently market its share.

The joint venture partners continued to evaluate samples from the AK-1 kimberlite pipe, where production is expected to begin in 1985 or 1986 and build to 20,000,000 carats per year. A feasibility study is completed.

At year-end, iron ore producers expected even more difficult times in 1983 than they experienced in 1982. In May of this year, expectations were confirmed when contract prices renegotiated with Japanese fell by 12 to 13 percent from previous levels. Hamersley Iron Pty. Ltd.'s stockpiles have increased from 8,100,000 to 13,400,000 metric tons.

Australian gold production increased 50 percent in 1982, most of the increase coming from this state. Kalgoorlie Mining Associates at Kalgoorlie produced at a level of 64,000 ounces of gold per year from the Mt. Charlotte and Fimiston mines. Substantial investment in new shafts and new treatment facilities is continuing.

At Kambalda, Western Mining Corporation is producing at a rate of approximately 51,400 ounces of gold per year. The company's carbon-in-pulp plant for treating the gold ores is located near Western Mining's nickel concentrator in the Kambalda area. The Telfer mine of Newmont Mining and Broken Hill Pty. Company Ltd. (BHP) produced 162,810 ounces in 1982, an increase of 24 percent over 1981.

Many hopeful mining companies are seeking gold and finding some in the band of country from North Kalgurli through Paddington and localities with evocative names like Broad Arrow, Menzies, Leonora, Laverton, Marvel Loch, and Big Bell. Nothing yet suggests that another Golden Mile will be discovered, but hopes continue that there are repetitions south and west of Kalgoorlie. Favorable reports have come from Whim Creek Consolidated further north of Kalgoorlie.

An active exploration program by a consortium comprised of Amax Exploration (Australia) Inc., Aztec Exploration Limited, and Esso Exploration and Production Australia Inc. continued through the year at Golden Grove, some 210 kilometers (131 miles) east of Geraldton. Drilling was concentrated in the Scuddles zinc deposit area, north of the Gossan Hill copper lodes. Preliminary reserve estimates classify protore into three categories: zinc zone, 6,200,000 tons of material grading 0.3 percent copper, 11.4 percent zinc, 1.0 percent lead, 2.7 ounces silver and 0.02 ounce gold per ton; copper zone, 4,900,000 tons of material grading 2.6 percent copper, 0.2 ounce silver and 0.006 ounce gold per ton; and the southern (merged) zone, 10,000,000 tons of 1.1 percent copper, 10.2 percent zinc, 0.7 percent lead, 2.8 ounces silver and 0.05 ounce gold per ton.

Although Esso withdrew from the joint venture uranium project with Western Mining at Yeelirrie, Western Mining continued to operate the pilot plant there, but may be forced by government policy to abandon the project. Planned production was to have been 2,500 tons of U_3O_8 and 2,000 tons of vanadium per year.

Greenbushes Tin Ltd. reduced the rate of development of its new mine at Greenbushes. The 20,000,000-ton tantalum ore body there is considered to be the world's richest. An important lithium deposit, containing an estimated 30,000,000 tons, has also been defined.

Alumina production at refineries south of Perth was reduced by Aluminum Company of America (Alcoa). A new plant at Wagerup is on a care and maintenance basis. Nevertheless, there is abundant confidence in the future. An agreement in principle between Alcoa and Korean interests for a future smelter has been approved. Studies are being made for a refinery near Geraldton to treat bauxite from Mitchell Plateau.

SOUTH AUSTRALIA

The Western Mining-BP Minerals Australia Pty. Ltd. consortium's Olympic Dam project continues to draw attention. The copper-uranium-gold prospect has been the target of concern by environmentalists and some government factions because of the uranium. Development of Olympic Dam would involve a $1,400,000,000 project to mine and mill 6,500,000 tons of ore per year for production of some 150,000 tons of copper, 3,000 tons of U_3O_8, 110,000 ounces of gold, and 736,000 ounces of silver. Reserves are estimated at 2,000,000,000 tons of material containing 1.6 percent copper, 0.02 ounce gold, and 1.3 pounds uranium per ton. Substantial tonnages of higher-than-average grade occur near the Whenan exploratory shaft and it may be desirable to mine this tonnage early to achieve cash flow.

The state government decided not to approve development of the Honeymoon and Beverley uranium deposits on environmental and safety grounds. MIM Holdings Ltd., CSR Ltd., and Teton Australia were considering an in situ

Production of selected minerals, ores, and metals in metric tons in Australia

Commodity	1980	1981	1982
Bauxite	27,179,000	25,541,000	23,622,000
Coal:			
Black	93,664,000	111,700,000	107,538,000
Brown	32,894,000	32,959,000	37,811,000
Copper in mine products	243,540	227,874	246,770
Iron ore and concentrate	95,534,000	84,718,000	87,790,000
Lead in mine products	393,491	388,642	456,719
Zinc in mine products	495,312	517,405	662,941
Gold in mine products (ounces)	600,077	618,059	812,880
Silver in mine products (ounces)	27,048,667	25,505,288	28,946,000
Manganese ore	1,999,000	1,409,387	1,132,202
Nickel in mine products	74,323	74,475	88,553
Tin in mine products	11,588	12,267	12,203
Tungsten (WO_3 units)	450,840	420,108	326,417
Ilmenite concentrate	1,384,563	1,332,277	1,157,989
Rutile concentrates	311,744	229,425	218,400
Zircon concentrates	491,547	424,688	452,765
Sulphur content (of pyrite and metallic concentrates)	350,476	356,490	439,259
Portland cement	5,497,000	5,946,000	5,744,000
Phosphate rock	6,621	21,997	235,000

1982 data are preliminary. Source: Bureau of Mineral Resources, Geology and Geophysics, Canberra A.C.T.

leaching project at Honeymoon to produce 450 tons of uranium oxide per year beginning in 1985 or 1986. Beverley joint venture partners Western Nuclear Australia Ltd., Oilmin NL, Transoil NL, and Petromin NL planned an in situ heap leaching project to produce 15,800 tons of uranium oxide over 23 years. Reserves at Beverley are 6,000,000 tons of ore grading 5.4 pounds uranium per ton.

NEW SOUTH WALES

Output of lead and zinc from the mines of Australian Mining and Smelting Ltd. at Broken Hill improved due to increased concentrator capacity and the treatment of larger tonnages of lower grade ore. Output by North Broken Hill Holdings Ltd. and Minerals Mining and Metallurgy Ltd. was steady. North Broken Hill suspended shaft sinking toward the Fitzpatrick zone.

EZ Industries Ltd.'s Elura mine, 40 kilometers (25 miles) north of Cobar, began production of zinc, lead, and silver. Elura is the first metal mine to be commissioned in this state since Woodlawn Mines began production from its complex copper, lead, zinc, and silver ore bodies in 1973.

Peko Wallsend Investment Ltd.'s porphyry copper deposit at Goonumble, near Parkes, 300 kilometers (190 miles) northwest of Sydney, will be explored and developed by Chevron Exploration Corporation. Peko has indicated that more than 250,000,000 tons of 0.7 percent copper and 0.009 ounce gold per ton in a 1,820-square kilometer (700 square miles) area. Certain zones, north and south, are excluded from the agreement with Chevron.

The CSR-led consortium building an aluminum smelter at Tomago is encouraged by recent market trends. The BHP Lochinvar smelter project is dead and buried. Alcan Australia Ltd. cut back production at Kurri Kurri and deferred a proposed third potline.

QUEENSLAND

Bauxite sales from Comalco Ltd.'s Weipa mines were down, partly because of a single labor dispute concerning a coal carrier. Queensland Alumina Ltd. closed one of its three digesters at Gladstone, but is raising nominal plant capacity from 2,030,000 to 2,330,000 tons per year. This increase is likely to yield 2,700,000 tons per year, if past performance is repeated. The nearby Boyne smelter was commissioned in February and is increasing output toward the planned 206,000 tons of metal per year.

Mary Kathleen Uranium Ltd.'s mine finally ceased production. The plant was auctioned successfully and the site is being made environmentally acceptable.

TASMANIA

Renison Ltd.'s tin mine operated below capacity because of planned shutdowns. Ore production was down from 1981 by about 10,000 tons to 642,852 tons, but with a lower grade of 1.16 percent tin versus 1.20 percent tin in 1981. Tin production fell from 5,546 to 5,152 tons in 1982. Construction of a fuming plant was deferred. At year-end, proven reserves were 5,965,000 tons grading 1.14 percent tin.

The Que River base and precious metals deposit of Aberfoyle Ltd. increased ore production from 89,694 in 1981 to 192,241 tons in 1982. Average grade of the ore, which was processed at EZ Industries' nearby Rosebery mill, was 0.6 percent copper, 8.4 percent lead, 16.3 percent zinc, 6.3 ounces silver per ton, and 0.13 ounce gold per ton.

Expansion of EZ Industries' Risdon zinc refinery has been completed and current capacity is 210,000 tons per year of refined zinc. A significant amount of byproducts will be refined here as well.

VICTORIA

At Stawell, Western Mining and Central Norseman Gold Corporation continue to drill and develop a promising gold deposit. No reserve figures have been released. At Benambra, Western Mining and BP Australia appear to be marking time until metal prices improve.

NORTHERN TERRITORY

The Ranger uranium mine and plant of Energy Resources of Australia Ltd. have more than lived up to expectations. The output in 1982 was 3,135 tons of U_3O_8 from a plant with a nominal capacity of 3,000 tons. Infill drilling upgraded quantity and quality of reserves to about 51,000,000 tons grading 0.247 percent U_3O_8 at year's end.

In line with a slack world steel industry, the demand for manganese ore from the Groote Eylandt mine remained depressed. Production was 1,132,000 tons; exports were 921,000 tons.

Peko's copper flash smelter at Tennant Creek remained closed and production from the Warrego mine declined. Gold production from the group's mines is about 100,000 ounces per year.

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Shipments of iron ore and pellets by Australian mining companies and mines

Mine	1977	1978	1979	1980	1981	1982
BROKEN HILL PROPRIETARY COMPANY LTD.[1]						
Cockatoo —		—	730,000	1,174,000	779,000	84,000
Koolan —		1,590,000	2,281,000	1,517,000	1,950,000	1,851,000
Koolanobbing	8,500,000	1,110,000	1,386,000	1,695,000	830,000	728,000
Iron Monarch —	—		2,470,000	864,000	748,000	1,073,000
Iron Prince, Iron Baron —	—		1,821,000	1,789,000	1,073,000	2,091,000
Total	8,500,000	5,900,000	7,526,000	6,528,000	3,937,000	4,669,000
CLIFFS ROBE RIVER IRON ASSOCIATES[2]						
Pellets	3,741,104	4,210,326	3,394,057	1,046,175	33,823[4]	80,226[4]
Fines	9,154,549	8,085,928	9,628,263	13,550,349	12,424,052[4]	14,001,962[4]
Total	12,895,653	12,296,254	13,022,320	14,596,524	12,424,052[4]	14,082,188[4]
HAMMERSLEY IRON PTY. LTD.[3]						
Mount Tom Price	21,141,000[4]	29,445,000[4]	19,855,000	—	—	—
Paraburdoo	12,778,000[4]	13,726,000[4]	12,939,000[4]	—	—	—
Total	34,867,000[1]	29,445,000[1]	32,824,000	38,950,000	29,100,000	28,300,000[1]
MOUNT GOLDSWORTHY IRON ORE JOINT VENTURE[2]						
	6,517,225	6,600,000	6,960,018	5,370,356	5,546,655[5]	5,000,000[5]
MT. NEWMAN MINING CO. PTY. LTD.[2]						
Mt. Newman	28,540,145	31,265,800	30,579,800	27,679,154[5]	27,753,423[5]	29,693,777[5]
SAVAGE RIVER MINES LTD.[2]						
Savage River pellets	2,180,850	2,027,823	2,158,730	2,273,679	2,215,000	2,082,220

1. Metric tons. 2. Long tons. 3. Includes pellets. 4. Gross tons. 5. Wet metric tons.

CANADA

By **R. H. Lemay**
Information Systems Division
Minerals Policy Sector
Energy, Mines & Resources
Ottawa, Ontario

The Canadian minerals industry succumbed to the impact of worldwide economic recession in 1982, with demand and selling prices for many key minerals declining sharply. The widespread reduction in demand for almost all mineral commodities forced production cutbacks through temporary mine closures, extended mine closures, and eventually, many permanent shutdowns. As a result, almost half of the domestic industry's employees were laid off, and there were financial losses for many major companies; for some of these companies 1982 was the first year of losses since the early 1930's.

Total Canadian mineral production, including metals, industrial minerals, and fuels, reached US$26,500,000,000 in 1982, compared with a total of US$25,800,000,000 in 1981, a slight increase of 2.5 percent. The metals industry, however, suffered a severe decline, dropping to $5,600,000,000 compared with $7,000,000,000 the previous year; this is a drop of almost 20 percent. Nonmetals dropped from US$2,100,000,000 in 1981 to US$1,700,000,000 in 1982.

The metals sector, being the most sensitive to business cycles, suffered severely. Canadian iron ore producers saw both value and volume of output drop by 30 percent during the year, and faced stiff competition for their products from countries such as Brazil. Reduced world demand for imports of iron ore from Canada culminated in the planned permanent closure of the Iron Ore Company of Canada's operations at Schefferville, Quebec in June 1983. Total output of iron ore for the year reached only 34,496,000 tons, compared with 49,551,000 tons in 1981, and a far cry from record level of 60,185,000 tons in 1979.

With almost 60 percent of copper consumed by the housing, home appliance, and automobile industries in the form of electrical wiring, tubes, and pipes, the refined copper market was severely depressed. As a result, mine production dropped from 691,328 tons in 1981 to 606,202 ton in 1982, a fall of 12 percent. Prices were also 12 percent lower, resulting in a drop in the value of production from US$1,200,000,000 to US$960,000,000.

Tons of ore mined and waste stripped at selected open pit mines in Canada

Company	Mine	1980 Ore Mined	1980 Waste Stripped	1981 Ore Mined	1981 Waste Stripped	1982 Ore Mined	1982 Waste Stripped
Advocate Mines	Baie Verte	1,896,000	12,104,000	N.A.	N.A.		
Afton Mines	Kamloops Operation	3,390,000	19,410,000	3,110,000	18,220,000	1,129,897[5]	N.A.
Asbestos Corp. Ltd.	British Canadian	3,557,000	11,140,800	2,615,223	8,228,007	1,900,000	5,600,000
	King Beaver	2,307,700	4,344,200	1,968,160	3,646,171	1,400,000	2,800,000
Bethlehem Copper Corp.	Iona / Jersey Pit Extension	7,505,636	15,146,052	7,908,412	15,281,384	N.A.	N.A.
Brenda Mines Ltd.	Brenda Mine	10,060,000	10,048,500	11,242,700[6]	11,734,000	10,454,830[8]	8,842,650
Cassiar Asbestos Co. Ltd.	Cassiar Mine	1,109,330	7,212,541	1,710,432	4,781,494	N.A.	N.A.
Cleveland-Cliffs Iron Co.	Adams Mine[1]	5,054,604	3,839,181	5,054,000	3,840,000	1,000,000	
	Sherman Mine[1]	4,214,401	8,005,981	4,214,000	8,006,000	1,000,000	
Cyprus Anvil Mining Co.	Anvil Mine	2,825,000	8,376,663	3,587,000	23,868,000	775,000[5]	10,513,000[5]
Equity Silver Mines Ltd.		—	—	1,910,000		2,073,000	
Gibraltar Mines Ltd.	Gibraltar Mine	38,510,000	14,801,000	27,141,000	N.A.	13,379,000	N.A.
Highmont Operating Corp.	Highmont Mine	850,000	7,500,000	7,767,870[6]	10,049,780[6]	12,947,200	12,796,560
Iron Ore Co. of Canada	Carol Project	51,588,261	8,143,674[1]	51,588,261	8,143,674[1]	12,800,000	N.A.
	Knob Lake Mine	9,562,732	9,039,015	6,793,928	6,241,725	2,300,000	—
Lac d'Amiante du Quebec, Ltee.[2]	Black Lake[4]	4,033,132	9,787,589	4,131,603	9,988,268	3,857,059	9,011,533
	National[7]	2,236,275	5,205,327	2,391,453	5,041,105	2,158,653	4,280,534
Lornex Mining Corp.	Logan Lake	17,678,000	41,557,000	22,861,000	70,488,000		
Newmont Mines Ltd.	Copper Mountain	107,000	2,010,000	3,645,000	5,445,000		
Similkameen Div.	Ingerbelle	7,289,000	10,566,000	3,926,000	363,000		
Noranda Mines Ltd.	Bell Mine	5,525,000	8,631,000	5,985,000	9,302,000	3,720,000[8]	N.A.
	Boss Mountain	274,397	32,250	9,330	833,825	76,440	218,485
	Granisle Mine	3,518,983	10,172,521	4,155,770	8,346,612	2,073,000[8]	N.A.
	Mont Copper	9,783,000	N.A.	N.A.	N.A.	N.A.	N.A.
	Mont Needle	1,489,000	—	N.A.	N.A.	N.A.	N.A.
Pamour Porcupine Mines Ltd.	Timmins Division	202,000	—	N.A.	—	143,630	—
Pine Point Mines Ltd. Cominco Ltd.	Pine Point Operations	3,626,000	13,100,000	3,600,000	21,700,000	2,445,000[8]	N.A.
Placer Development Ltd.	Endako	11,451,000	13,193,000	10,523,800	11,818,800	2,847,000	6,025,000
Quebec Cartier Mining Co.	Mount Wright[3]	33,278,000	33,278,000	30,763,000	30,648,000	21,892,000	18,179,000
Syncrude Canada Ltd.	Mildred Lake Operations[2]	73,800,000	47,700,000	N.A.	N.A.	N.A.	N.A.
Utah Mines Ltd.	Island Copper Mine	15,300,000	44,700,000	15,500,000	41,900,000	N.A.	N.A.
Wabush Mines	Scully Mine	6,395,496	4,893,510	N.A.	N.A.	N.A.	N.A.

1. Cubic yards. 2. Metric tons. 3. Long tons. 4. Figure includes 2,700,000 low grade to stockpile. 5. Shut down June 4, 1982. 6. Shut down for 34 days in 1982. 7. Shut down for 65 days in 1982. 8. Tons milled. 9. Year ended September 20th. All figures in short tons unless otherwise specified. 1.0 short ton = 0.907 metric ton = 0.893 long ton. 1 metric ton = 1.10 short tons. 1 long ton = 1.12 short tons. N.A. Not Available.

Canadian Mineral Production

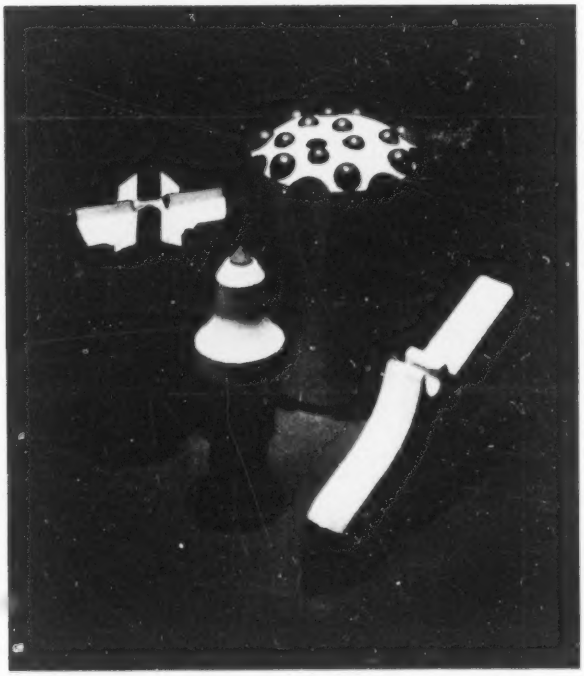
Commodity	1980	1981	1982[4]
Metallic minerals			
Bismuth[1]	148,000	168,000	126,000
Cadmium[1]	1,033,000	834,000	739,000
Cobalt[1]	2,118,000	2,080,000	1,458,000
Columbium (Cb_2O_5)[1]	2,463,000	2,741,000	3,126,000
Copper[1]	716,363,000	691,328,000	606,202,000
Gold[2]	50,620,000	52,034,000	62,456,000
Iron ore[3]	49,068,000	49,551,000	34,496,000
Lead[1]	251,627,000	268,556,000	290,292,000
Molybdenum[1]	11,889,000	12,850,000	8,590,000
Nickel[1]	184,802,000	160,247,000	88,745,000
Platinum group metals	12,776,000	11,902,000	8,590,000
Selenium	279,000	255,000	198,000
Silver[1]	1,070,000	1,129,000	1,204,000
Tellurium[1]	15,000	31,000	19,000
Tin[1]	243,000	239,000	153,000
Tungsten (WO_3)	4,007,000	2,515,000	3,053,000
Uranium (U) [1]	6,739,000	7,507,000	8,189,000
Zinc[1]	883,697	911,178	1,302,653
Industrial Minerals & Coal			
Asbestos[3]	1,323,000	1,122,000	822,000
Cement[1]	10,274,000	10,145,000	8,418,000
Coal[3]	36,668,000	40,088,000	43,200,000
Gypsum[3]	7,336,000	7,025,000	5,726,000
Potash (K_2O)[3]	7,201,000	6,549,000	5,196,000
Nepheline Syenite[1]	600,000	588,000	518,000
Pyrite[3]	32,000	10,000	20,000
Sulphur, elemental[3]	7,656,000	8,018,000	7,108,000

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
1. Kilograms 2. Grams 3. Metric tons. 4. Preliminary.
1.0 metric ton = 1.0 short tons, 0.0326 x grams = troy ounces.

Tons of ore mined from selected underground mines in Canada

Company	Mines	1980	1981	1982
Algoma Steel Corp. Ltd.	George W. MacLeod Mine	2,529,000	2,270,000	1,360,000
Allan Potash Mines	Allan Operations	N.A.	1,103,000[3]	N.A.
Asarco, Inc.	Buchans Unit	83,000	68,946	—
Bachelor Lake Gold Mines Inc.	Bachelor Lake	—	—	63,178
Bell Asbestos Mines Ltd.	Bell Mine	955,960	1,210,000	N.A.
Brunswick Mining and Smelting Corp. Ltd.	#12	1,979,500	3,532,891	3,928,448
	#6	110,743	24,531	109,837
Camflo Mines Ltd.	Camflo Mine	462,952	463,000	463,845
Campbell Red Lake Mines Ltd.	Red Lake Mines	304,000	369,500	335,223
Canada Wide Mines Ltd.	Granduc	—	—	544,576
Cominco Ltd.	Con Mine	212,000	194,000	234,200
	Polaris	—	—	518,000
	Sullivan Mine	2,087,000	2,436,000	2,446,000
	Vade Mine[1]	1,009,000	3,245,785	2,433,310
Canada Tungsten Mining Corp. Ltd.	Tungsten	344,501	N.A.	N.A.
Craigmont Mines Ltd.	Merritt Operations	2,105,000	2,151,000	—
Dankoe Mines Ltd.	Horn Silver Mine	23,851	N.A	N.A.
Denison Mines Ltd.	Elliott Lake Operations	2,440,020	3,711,822	4,362,348
Dickinson Mines Ltd.	Red Lake	—	—	171,906
Dome Mines Ltd.		678,000	557,200[3]	707,600
Falconbridge Copper Ltd.	Opemiska Div.	1,059,000	936,555[4]	N.A.
Falconbridge Nickel Mines Ltd.	East	240,259	234,471	143,100
	Falconbridge	620,476	484,108	258,240
	North	—	95,636	51,486
	Fraser Mine[1]	13,188	33,104	102,193
	Lockerby	393,981	516,420	253,663
	Onaping	199,186	95,950	43,786
	Strathcona	1,776,441	1,575,391	88,500
Giant Yellowknife Mines	Yellowknife	227,240	227,240	358,235
Hudson Bay Mining and Smelting Co., Ltd.	Anderson Lake Mine	144,376	162,823	146,428
	Centennial Mine	139,133	197,147	153,728
	Chisel-Ghost Lake	242,412	236,401	224,489
	Flin Flon Mine	665,530	634,709	499,526
	Osborne Lake Mine	182,186	197,799	155,583
	Stall Lake Mine	265,733	253,011	231,202
	Westarm Mine	173,055	171,789	148,580
	White Lake Mine	62,944	79,730	43,513

Survivors.



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The nickel industry fared no better. Its crisis was underlined by Inco Ltd.'s decision to extend the shutdown of its mines and plants in Sudbury, Ontario from June 1982 to April 4, 1983. Prices plummeted with Western World demand—quoted producer prices remained at $3.20 per pound, but fluctuations were widespread, and a more realistic level was between $2.50 and $2.60 per pound. North American producers cut production drastically, causing the average utilization of capacity to fall below 70 percent. Canadian production fell all the way to 88,745 tons in 1982, down 45 percent from the 1981 level of 160,247 tons. Production value plunged 53 percent, going from US$990,000,000 in 1981 to some US$465,000,000 in 1982.

Molybdenum, a victim of an ailing steel industry, faced severely reduced demand. More than a year's supply of molybdenum was already available worldwide. Production in Canada continued to hold pace, rising to 15,232 tons in 1982 from 12,850 tons in 1981, but markets were difficult to find.

Lead production increased slightly to 290,292 tons in 1982 from 268,556 tons in 1981, but the value of that output dropped 20 percent. Zinc fared somewhat better, with a 13 percent increase in volume and a corresponding 2-percent increase in output value, but the unit

International Minerals & Chemical Corp.	K1-K2, Saskatchewan	11,424,000	10,996,640	8,374,966
Kerr Addison Mines Ltd.	Kerr Addison	215,000	882,000	662,000[7]
Long Lac Minerals Ltd.	Doyen	—	—	383,608
	Thompson Bousquet	—	—	523,621
Mattabi Mines Ltd.	Sturgeon Lake	—	—	422,600
Nanisvik Mines Ltd.	Baffin Island	—	—	624,275
Newfoundland Zinc Mines Ltd.	L. Zone	572,143	605,882	559,140
Noranda Mines Ltd.	Boss	258,857	467,759	336,645
	Central Canada Potash	3,752,000	3,406,000	1,821,000
	Geco Division	1,497,288	1,466,000	1,489,000
	Heath Steele	—	1,378,000	1,542,000
	Lyon Lake	—	359,000	261,000
	Mattagami Lake	915,146	961,035	968,575
	Mont Needle	489,000	N.A.	N.A.
	Norita Mine	329,273	289,512	289,026
	Orchan Mine	95,528	76,023	40,967[8]
	Radiore #2	124,319	124,319	N.A.
Northgate Exploration Ltd.	Copper Rand	—	622,786[9]	557,609
	Portage	—	116,593	173,512
Pamour Porcupine Mines Ltd.	1 Division	618,231		
	3 Division	94,772	1,758,000	1,637,000
	Ross Division	204,140		
	Schumacher Division	514,370		
Potash Corp. of Saskatchewan Mining Ltd.	Lanigan Division	2,335,421	2,250,000	N.A.
Rio Algom Ltd.	Quirke Mine	2,340,000	2,454,990	N.A.
	Panel	N.A.	1,139,895	N.A.
Sherritt Gordon Mines Ltd.[11]	Fox	864,224	808,587	417,453
	Ruttan	876,629	1,584,903	864,612
Tantalum Mining Corp. of Canada, Ltd.	Bernic Lake	184,000	290,000	N.A.
Sigma Mines (Quebec) Ltd.		—	—	441,980
Teck Corporation	Beaverdell	—	40,435	40,217
	Lamaque	289,644	435,520	318,338
	Niobec	—	762,838	809,242
	Silverfields Silver	—	85,902	762,838
Kidd Creek Mines Ltd.		4,136,939	4,493,400	4,076,359
Union Miniere et Exploration	Umex-Thierry Mine	937,415	1,100,000	—[10]
Western Mines Ltd.	Lynx, Myra Mines	306,712	317,002	271,334[9]
Whitehorse Copper Mines Ltd.	Little Chief	854,300	819,766	726,091

1. Metric tons. 2. Short wet tons. 3. Closed for 2 months due to strike. 4. Closed for 5 weeks due to strike and 2 weeks at Christmas. 5. July 1, 1980—June 30 1981. 6. Closed October 1982. 7. Includes Mogul of Ireland. 8. 1981 production low due to 6 weeks strike. 9. No production for October 1981 due to labor strike. 10. Mine shut down. 11. Both mines cut production to about 2/3rds in January 1982. Both were closed for 3 months in the summer of 1982. N.A. Not Available.

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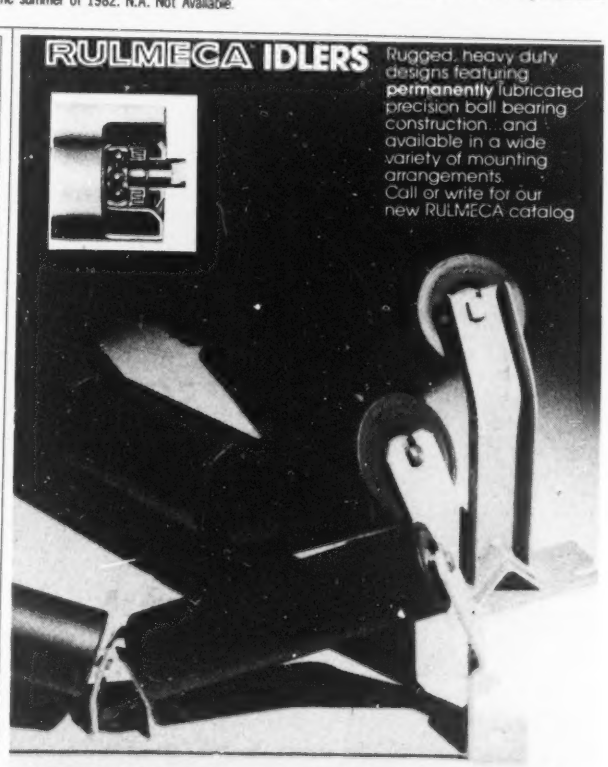

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price of the metal suffered with the slowdown in industrial activity.

The only encouraging growth in metals appeared in the gold mining sector, as prices above $400 continued to make exploration and production attractive. Fluctuations below that price level appeared as a result of pressures in financial markets, and no strong movement upward occurred during the year. The quantity of gold produced increased to 62,456,000 grams (2,036,000 ounces), valued at US$743,000,000, respective increases of 20 and 1 percent from 1981 production.

Exploration activity was very apparent, with the Hemlo area of northwestern Ontario being the most prominent. A major gold project at Detour Lake, Ontario slated to come on-stream in August 1983, was ahead of schedule. Gold and silver mines provided some relief to the income statements of companies that produced them as byproducts of their copper, nickel, lead, and zinc operations.

Non-fuel minerals production

	1981 ($1,000,000)	1982	Change (percent)
Metals	8,684	7,053	−18.8
Nonmetals (excluding coal)	2,707	2,154	−20.4
Structural materials	1,769	1,573	−11.4
Total	13,160	10,730	−18.1

The uranium industry, also a victim of oversupply and general economic conditions, was plagued by lower sales and weak prices, leading to the closure by Eldorado Nuclear Ltd. of its Beaverlodge operation in Saskatchewan. However, the Elliot Lake region, the largest producing area in Canada, operated profitably on contracts negotiated prior to the recession. Production reached 8,178 tons, up 9 percent from 1981.

Mining companies responded to the prolonged recession during the year with measures aimed at cutting costs, including production cutbacks, cancellation of capital expenditure programs, and significantly reduced exploration. New capital expenditures in metal mining totalled US$1,040,000,000 in 1982, compared with US$1,500,000,000 in 1981.

With the Canadian minerals industry so heavily export-oriented (almost 80 percent of minerals and mineral products are destined for world markets), the state of the world economies played a significant role. The United States purchased approximately 55 percent of mineral exports in 1982, compared with 59 percent the previous year.

For many years Canada has been the western world's largest exporter of minerals, the value of which has contributed almost 20 percent of total export earnings. Dependent on international markets, the health of the mining industry will improve when economic recovery in the western industrialized countries occurs. Most analysts see that improvement coming in mid-1983. Real growth in economic activity in the United States should be apparent by the second quarter of 1983, thereby stimulating demand for Canadian minerals.

Recovery, when it does occur, will have an initial impact on those minerals that have kept close pace with demand. Copper, lead, and zinc will show improvement quickly as inventory levels are low. Iron ore and molybdenum will suffer into the mid-1980's. Once sustained evidence of increased demand is available, metal prices will move upwards.

Although world consumption of minerals is not forecast to grow in future years at the same rate as in the past, the overall demand will increase with continued industrialization. As the world's largest producer of nickel, zinc, potash, and asbestos, and the second largest producer of molybdenum and uranium, the Canadian minerals industry will continue to prosper.

Despite the gloom, minerals are essential industrial commodities and will continue to be needed in great quantities. A slow 1983 and a more promising 1984 appears to be the condition facing the Canadian mining industry.

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CARIBBEAN

CUBA

Cuba appears determined to double nickel production and sales by 1985, to 70,000 tons. Cubaníquel campaigned in Western Europe in 1982. There were some reports that British Steel Corporation was considering purchasing nickel from Cuba; at present, about 75 percent of production is sold to the Soviet Union.

Cuba plans to complete the first production line of its Punta Gorda nickel plant in 1984. The plant's design capacity is 33,000 tons per year. A 20-ton per day pilot plant for nickel-cobalt laterite ores was also under construction at Punta Gorda, and is expected to be completed in mid-1983.

Work on Los Camariocas plant seems to have been postponed indefinitely.

Cuba's two pre-revolution, United States-built nickel plants are now operating close to capacity. The Nicaro plant, with an annual capacity of 25,000 tons of nickel oxide, was producing between 17,500 and 20,000 tons at the end of 1982. The Moa Bay plant was producing about 12,500 annual tons of nickel sulphide.

DOMINICAN REPUBLIC

The Falconbridge Dominicana ferronickel plant reopened at 50 percent of its 31,500-ton per year capacity in mid-September 1982, after an eight-month shutdown. Production resumed when inventories had dropped to 2,000 tons.

The plant shipped 6,045 tons of nickel contained in concentrate in 1982, compared to 20,590 tons in 1981. Proven and probable reserves of laterite ore at the end of 1982 were 46,000,000 tons grading 1.78 percent nickel.

Surface diamond drilling at Falconbridge's Cerro de Maimon prospect, a few kilometers southeast of the plant, was completed in 1982. At a 1 percent cut off, near-surface mineralization contains 3,200,000 tons of material averaging 4.05 percent copper, 1.93 percent zinc, 1.3 ounces silver, and 0.014 ounce gold per ton.

Rosario Dominicana S. A.'s Pueblo Viejo mine produced 378,614 ounces of gold and 2,112,313 ounces of silver in 1982, compared to 412,992 ounces of gold and 2,061,816 ounces of silver in 1981. Rosario estimates production costs at $105 per ounce, the world's lowest when compared to similar operations.

The United Nations is providing technical assistance to the government to evaluate alluvial gold deposits that are located in the Miches region. Small miners have been recovering gold in the area for decades.

HAITI

Reynolds Haitian Mines Inc., the only bauxite producer in Haiti, permanently shut down its bauxite operation in September 1982 because of depleted reserves. The wholly-owned subsidiary of Reynolds Metals Company's produced 376,721 dry metric tons in 1982.

The mine began production in 1957, and produced between 600,000 and 700,000 tons of bauxite per year.

JAMAICA

Jamaica began and ended the year with good news—two large bauxite contracts and several countertrade agreements were signed with the United States. But the year as a whole was a dismal one. Bauxite mines and alumina plants continued to reduce production levels. Bauxite production fell 28.2 percent, to 8,334,392 metric tons, bauxite exports dropped 23.8 percent, to 4,033,209 tons, and alumina exports were down 31 percent, to 1,757,610 tons.

Jamaica has been particularly hard hit cutbacks by aluminum companies overseas. The United States was the sole market for Jamaica's bauxite in 1982 and the two companies that import bauxite from Jamaica—Kaiser Aluminum and Chemical Corporation and Reynolds Metals Company—drastically cut operating capacity to 26 and 43 percent, respectively. The situation was worsened by the fact that Kaiser and Reynolds have concentrated most of their cutbacks in the high-energy-cost, Gulf Coast region to which Jamaica's bauxite is shipped.

Alumina shipments were down because of weakened demand, but the difficulties were again exacerbated by operation cutbacks. Most significant was the closure of British Aluminium Company Ltd.'s Invergordon smelter in Scotland, which imported 200,000 tons of alumina per year. The cutback at the Volta Aluminium Company Ltd. (Valco) smelter in Ghana also hurt.

Jamaican bauxite and alumina production and shipments, metric tons

Commodity	1980	1981	1982
Bauxite exported	6,059,798	5,294,089	4,033,209
Bauxite converted to alumina	5,918,506	6,311,930	4,301,183
Total bauxite produced	11,978,304	11,606,020	8,334,392
Alumina exported	2,395,082	2,549,855	1,757,610

1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

Exports of bauxite would have been much worse without imports by the United States government. Early in 1982, the United States General Services Administration (GSA) acquired 1,600,000 dry long tons of bauxite for the national defense stockpile. About 1,200,000 tons were bought, and the remainder bartered for dairy products. At the end of the year, the GSA purchased an additional 1,000,000 tons.

Also late in 1982, General Motors Corporation signed a countertrade agreement with the Bauxite & Alumina Trading Company. Over three years, 270,000 tons of alumina will be traded for motor vehicles, heavy equipment, and machinery. A similar agreement was reached with Chrysler Corporation—50,000 tons of alumina for trucks.

The Soviet Union agreed to purchase 1,000,000 tons of bauxite per year over a seven-year period, beginning in 1984. The new contract replaces an earlier agreement for 250,000 tons of alumina per year for seven years.

PUERTO RICO

Producers of all major mineral commodities reported a continuing slump in demand and sales in 1982. The value of Puerto Rico's nonfuel mineral production in 1982, excluding sand, gravel, and stone, was $92,000,000, compared to $195,815,000 in 1981.

TRINIDAD TOBAGO

A proposed 180,000-ton per year aluminum smelter project is on hold until the market improves. National Steel Corporation and Southwire Company are expected to be the joint venture partners, along with the government. The smelter would be built at an industrial site at Point Lisas.

VIRGIN ISLANDS

Martin Marietta Corporation completed a conversion of its St. Croix alumina smelter from oil to coal in December 1982. The use of coal is expected to reduce costs by about 40 percent.

In 1981 the smelter was expanded to produce 700,000 tons of alumina per year. Production in 1982 was 650,000 tons, up from 579,000 tons in 1981.

AUSTRIA

Better production was achieved in 1982 than in 1981. Iron ore production increased by 9.2 percent to a level of 3,330,000,000 tons at Steirischer Erzberg. Important non ferrous ores registered further production increases in 1982, above all, tungsten ore production increased by 14.9 percent, lead and zinc ore production by 5.4 percent and antimony ore production by 4.7 percent.

The Bleiberger Bergwerksunion AG (BBU) has doubled its lead-zinc ore production in the last ten years and reached 841,000 tons of ore in 1982. BBU found lead zinc mineralization associated with barite in argillaceous schists in the Graz palaezolic near Stubing northwest of Graz and explored this intensively. In 1982 another 4 tons of valuable germanium were produced. Raw ore production in the antimony mines of Schlaining increased and 95 percent of the production was exported.

In Arnoldstein (Karnten), BBU started operation of an automated scrap treatment plant. This installation enables the efficient and considerably higher recovery of lead, especially from car batteries, through automatic separation from other components.

Iron ore extraction at Steirischer Erzberg increased by 9.2 percent, whereas raw iron production fell by 10.4 percent and raw steel production by 8.5 percent.

Tungsten ore production in Mittersill (Salzburg) increased by almost 15 percent compared to 1981, which led to a higher yield of tungsten. In the tungsten plant of Bergla (Steiermark) tungsten metal powder and tungsten carbide was made from tungsten concentrate, mainly for export purposes.

In addition, the production of anhydrite increased by 3.8 percent in 1982, graphite production by 2.7 percent, talc and talc schist by 0.6 percent and volcanic breccia by 27 percent.

Saltbrine production of the four Salzberg mines in 1982 decreased by 11 percent, rock salt production at Alt-Aussee decreased by 18.4 percent compared to 1981; the three brine wells reached a production of over 433,000 tons of domestic salt, a decrease of 6.3 percent compared to 1981.

Due to lower demand, gypsum production decreased by 11.8 percent, quartz sands by 0.6 percent, quartz by 3.9 percent, and feldspar by 71.4 percent. Clay production decreased by 70 percent, whereas illite production increased by 100,000 tons or 33.2 percent due to higher demand.

Compared to 1981, kaolin production increased by 11.4 percent, quartz sand was also produced as a by-product with pure kaolin. Due to decreased market demand, magnesite and dolomite production also fell, by 11 and 16.1 percent respectively.

In terms of mineral product value, crude oil and gas were, again, the most important mith 48.5 percent of the total value. Rock and industrial mineral production followed with 29.9 percent, ore production 9.5 percent, coal 8.2 percent, and salt with 3.9 percent.

In 1982 there were a total of 88 active mines, not including the solution mines, compared to 90 in 1981. Of that total, the number of underground mines increased from 22 to 25 percent, open pit mines decreased from 66 to 65 percent, and 10 percent of the mines worked both underground and on surface.

Austrian production of ores, metals, and minerals in metric tons

Commodity	1980	1981	1982
Brown coal	2,864,967	3,061,262	3,297,488
Iron ore	3,200,000	3,050,000	3,330,000
Pig iron	3,485,161	3,477,257	3,114,985
Raw steel	4,623,773	4,655,503	4,258,156
Lead-zinc ore	694,545	797,654	841,027
Lead concentrate	5,447	5,465	5,168
Lead, metal	16,965	16,132	17,922
Zinc concentrate	32,658	31,479	32,934
Zinc electrolytic	22,102	22,674	23,000
Copper electrolytic	31,286	28,395	31,611
Antimony ore	24,698	26,527	27,784
Tungsten ore	458,804	357,287	410,577
Aluminum	94,393	94,219	93,908
Gypsum & Anhydrite	833,417	800,515	727,520
Graphite	36,699	23,807	24,451
Magnesite	1,318,156	1,158,852	1,031,404
Raw talc	116,708	116,425	117,092
Kaolin	340,980	316,560	351,392
Salt	410,130	462,485	433,557
Cement	5,455,454	5,287,604	5,011,988

1.0 short ton = 0.907 metric ton 1.0 metric ton = 1.10 short tons

BELGIUM

At the beginning of last year, the Belgian non-ferrous metals industry experienced its biggest shake-up since the nationalization of Union Minière du Haut Katanga's (UMHK) mines in Zaire, previously the Belgian Congo, over a decade ago. In brief, Union Minière S.A. (the successor to UMHK) was liquidated and a new Union Minière, wholly owned by Société Générale de Belgique (SGB), was created. SGB, a major Belgiam holding company, formerly had about 6 percent of Union Minière. All shareholdings in other mining companies are now held through Union Minière.

These shareholdings include Société de Prayon S.A., a zinc metallurgical company and important fertilizer producer. Prayon recently opened a plant in Belgium for the recovery of uranium from phosphate. Métallurgie Hoboken-Overpelt is the country's leading smelting and metallurgical company. Umican Inc. conducts Union Minière's activities in Canada, primarily the Thierry copper mine in Ontario. Union Mines Inc covers the interests in the United States, including zinc mines and participation in the Ocean Mining Associates deep sea mining consortium. União Miniera e Metalurgica Ltda is the Brazilian subsidiary, which controls the Tejucana diamond and gold dredging.

Finally, Union Minière also controls the country's two foremost zinc smelters and producers Société des Mines et Fonderies de Zinc de la Vieille Montagne S.A. and Compagnie Royale Asturienne des Mines. Since the initial shake-up, these two companies announced that they a merger with the intention of streamlining their operations. Vieille Montagne, one of the world's leading zinc metal producers, operates zinc plants in Belgium, France, and Germany and a zinc mine in Sweden. Asturienne has lead, zinc, and silver mines in Morocco and Spain and metallurgical plants in France, Morocco, and Spain.

BULGARIA

In 1982 the total production of the metallurgy and mineral resources sector of the national economy was 2.4 percent higher than in 1981. The results achieved are in compliance with the national program for the development of the energy and metallurgy sectors in the period 1980-1990.

The iron and steel industry produced 3,272 tons of rolled ferrous metals, 2,586 tons of steel and 1,619 tons of cast iron and ferroalloys in 1982. The reconstruction and the extension of the two metallurgical combines "Lenin" and "Kremikovtzi" was in full swing. In the Lenin Combine a new electric steel casting shop which is claimed to be one of the biggest in Europe is under construction. It will have four electric arc furnaces and three lines for continuous casting of steel with an annual capacity of 1,000,000 tons. Two of the furnaces went already into operation. In the Kremikovtzi combine new technologies for processing of steel outside of the furnace with argon, synthetic slag and vacuum

Bulgarian production of metals and minerals in metric tons

Commodity	1980	1981	1982[1]
Brown coal	6,900,000	6,700,000	6,600,000
Burnt gypsum	88,000	94,000	104,000
Cast iron and ferroalloys	1,583,000	1,571,000	1,617,000
Cement	5,400,000	5,400,000	5,600,000
Coke (6 percent moisture)	1,348,000	1,348,000	1,274,000
Copper	68,300	68,000	70,000
Hard coal	446,000	429,000	406,000
Iron ore (iron content)	500,000	537,000	474,000
Iron ore (mine tonnage)	1,886,000	1,754,000	1,552
Lead	121,300	121,000	121,000
Lignite	24,200,000	21,300,000	26,400,000
Manganese ore	49,000	45,000	45,000
Molybdenum[2]	330,000	330,000	330,000
Quick lime (burnt lime)	1,848,000	1,758,000	1,776,000
Raw gypsum	311,000	350,000	376,000
Refractory materials	184,000	190,000	171,000
Rolled ferrous metals	3,213,000	3,351,000	3,253,000
Silver[3]	771,000	800,000	800,000
Steel	2,565,000	2,484,000	2,584,000
Washed kaolin	208,000	221,000	137,000
Zinc	86,000	86,000	86,000

1. Estimates, American Bureau Metal Statistics. 2. Pounds. 3. Ounces. Source: Bulgarian Statistical Yearbook 1982. Pocket statistical Yearbook 1983. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

will be introduced. Under construction is also new coking battery No. 4.

Near the manganese deposits in the village of Oborishte, Tolboukhin district, a large mining and metallurgical works for the production of manganese ferroalloys using local raw materials, was put under construction.

Non-ferrous metallurgy also made considerable progress in 1982. New capacities were put into operation in the three main copper ore producing and processing combines "Elatzite", "Oscgovo" and "Assarel". The reconstruction of the Georgi Dimitrov copper smelter and metallurgical works, which is being undertaken in cooperation with Finnish companies.

Marble production in 1982 increased to a level twice as great as that in 1976. Near the rich deposits in Pirin mountain, estimated to about 35,000,000 cubic meters of marble, a new processing factory went on stream producing annually 300,000 square meters of slabs. Later on the capacity will be increased to 1,500,000 square meters of slabs. The cement industry produced 5,600,000 tons—a growth of 3.1 percent compared with 1981.

CYPRUS

By **G. C. Kronides**
Ministry of Commerce & Industry
Nicosia

There was no improvement in mining activity during 1982; this was the result of the continued depletion of ore reserves coupled with the slackening in demand for the main products—asbestos and copper.

The government through the Geological Survey Department carried out exploration for metallic and industrial minerals. Core drilling of 16 holes in mineral prospects was carried out and some mineralization was encountered encouraging further exploration.

The United Nations Revolving Fund project continued and terminated its exploratory work towards mid 1982. The work comprised geophysical and geochemical prospecting and drilling in Kambos and Kinousa areas. The final report on the activities of the Fund in Cyprus, submitted early in 1983, will contain recommendations for the continuance or termination of the project.

With the help of technical expertise from France and Germany, islandwide reconnaissance exploration was carried out with an aim to assess the potential of non-metallic minerals. Phosphates, industrial clays, decorative stones, carbonate fillers, gypsum and basaltic rock for mineral fibers were among the targets.

The Mineral Resource Map of Cyprus, has been published on a scale of 1 to 250,000. It has information on the Island's geology; mineral resources; locations, size, and types of mines and quarries; size, type, and grade of deposits; and export trends for the last 50 years.

The Cyprus Asbestos Mines Ltd. produced 18,952 metric tons of abestos fiber from their open pit mine at Troodos mountain.

The Hellenic Mining Company produced 28,089 tons of iron pyrites, 1,530 tons of cement copper, and 2,878 tons of chromite. Operations at the chrome mine ceased pending better prices. The company is carrying out exploration to increase its chromite ore reserves.

Cyprus minerals export in metric tons

Commodity	1980	1981	1982
Asbestos	29,965	29,000	19,112
Chromium ore and concentrate	6,889	9,670	11,051
Copper concentrate	812	—	—
Iron pyrite	88,028	35,670	1,100
Sulphite concentrate containing precious metals	570	600	190
Cement copper	—	—	2,010

1.0 long ton = 1.2 short tons. 1.0 short ton = 0.893 long ton.

CZECHOSLOVAKIA

In 1982, mining production remained at approximately the same level as the previous year. However, successful prospecting and exploration programs promise an increase in the future. This is primarily in connection with black coal in central Bohemia, tin-tungsten-lithium ore in the Kruené Hory mountains, mercury in Slovakia, and gold in the Vltava River valley.

Czechoslovakian production of ores, metals, and minerals in metric tons

Commodity	1980	1981	1982
Iron ore	1,927,000	1,935,000	1,984,000
Steel	15,225,000	15,270,000	15,266,000
Lead, metal	20,014	21,000	21,000
Zinc, metal	1,881	2,000	2,000
Copper, metal	31,000	30,000	30,000
Brown coal gross output	92,529,000	93,096,000	94,036,000
Lignite	3,197,000	3,269,000	3,351,000
Black coal net output	26,201,000	27,512,000	27,611,000
Coke	10,323,000	10,323,000	10,380,000
Cement	10,546,000	10,645,000	10,753,000
Limestone	23,894,000	24,136,000	24,290,000
Lime	3,018,000	3,234,000	3,357,000
Washed kaolin	650,000	652,000	651,000
Gypsum	757,000	767,000	788,000
Calcined magnesite for brickmaking	326,000	331,000	335,000
for steelmaking	339,000	333,000	341,000

1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

Steel production based mainly on imported iron ore from Krivoy Rog in the Soviet Union increased slightly. Domestic mining of iron ore from the Rudnany, Nizná Slaná, and other deposits in Slovakia has only a limited amount of economic importance.

Production of copper ore is mainly from the Devonian age Zlaté Hory stratiform deposit. Mining of copper ore continues at the Banská Stiavnica, Slovinky, Rudnany, Mária (near Roznava), and other Slovak deposits. Production of mercury from tetrahedrite in the Rudnany deposit is increasing substantially.

Cassiterite and tungsten ores are being extracted from the Horní Slavkov and Cínovec deposits, where new reserves of tin-lithium ores have been discovered. Stibnite ores are being extracted from the Dúbrava mine, in the Low Tatras, and the Pezinok mine, in the Little Carpathians in Slovakia.

In spite of the closure of some old lead-zinc mines in Bohemia, such as Príbram, the output of ore remains at previous levels. The main producers are the Horní Benesov, Kutná Hora, and Staré Ransko deposits in Bohemia and Banská Stiavnica in Slovakia. Positive results from geological exploration for polymetallic ores in eastern Slovakia may affect copper, lead, and zinc production in the future.

Great interest has focused on the extraction of non-metallic ores, mainly building materials; cement, lime, building stones, perlite, etc.; and refractory materials; magnesite, fire clays, and graphite. Output of traditional Czech glass sand is increasing slightly. The total output of fluorite and barite from several small deposits remained steady.

FINLAND

The total output of Finnish ore and mineral mines increased in 1982 by about 5 percent and was 19,200,000 tons. Pro-

duction of metalliferous ores totalled 9,800,000 tons, and minerals production 9,300,000 tons.

The list of major developments in Finland in 1982 includes:

- The expansion of the Siilinjärvi apatite mine was completed; annual output is now 5,000,000 tons of ore and 500,000 tons of apatite concentrate. Siilinjärvi is now Finland's largest mine.
- A plant to produce $CaCO_3$ pigments is being built in connection with the limestone quarry at Lappeenranta. Suomen Karbonaatti Oy started production at the plant in 1983 at a capacity of 25,000 tons per year.
- Partek Oy and Cementa AB started a joint venture limestone mine in Gotland, Sweden, to produce limestone for Finland.
- A long-term contract for the purchase of zinc concentrate from Spain was concluded by Outokumpu.

Imported raw materials required for the metallurgical industry, expressed as a percentage of annual metal production were; zinc concentrate 83 percent, nickel matte and concentrate 60 percent, iron concentrate 50 percent, cobalt concentrate 40 percent and copper concentrate 35 percent.

Finnish mine production in metric tons

Commodity	1980	1981	1982
OUTOKUMPU OY			
Ore mined	5,286,236	5,167,459	5,291,642
Copper concentrate[1]	144,[illegible]N	152,568	145,940
Pyrite concentrate	324,[illegible]00	261,352	288,422
Zinc concentrate	113,[illegible]85	h[illegible]5,478	109,214
Lead concentrate	2,[illegible]96	3,623	3,111
Nickel concentrate[2]	91,199	82,105	82,730
Chromium concentrate	186,540	201,949	185,160
Chromium lump ore	154,412	210,363	159,858
Zinc	146,719	139,835	143,882
Stainless steel	93,225	87,209	106,777
Copper (cathode)	40,542	33,796	47,969
Nickel (cathode)	12,807	13,310	12,615
Cobalt	1,151	1,229	1,455
Cadmium	581	621	566
Molybdenum	114	165	216
Mercury	75	67	71
Silver	44	38	37
Selenium	17	19	10
Gold	1.3	1.0	1.1
RAUTARUUKKI OY			
Ore mined	4,294,681	4,117,098	4,179,782
Iron concentrate	810,006	871,260	883,800
Ilmenite concentrate	159,000	161,500	167,800
Pyrite concentrate	8,150	7,530	6,700
Vanadium pentoxide	5,076	5,557	5,619
MYLLYKOSKI OY			
Ore mined	448,060	482,700	433,270
Copper concentrate[1]	11,638	12,130	9,089
Pyrrhotite concentrate	129,085	142,000	97,043
Cobalt-nickel concentrate	3,869	3,500	2,500
Zinc concentrate	2,748	2,950	2,330
Talc concentrate	27,403	41,447	66,000
Nickel concentrate	807	1,374	1,860
YHTYNEET PAPERITEHTAAT OY SUOMEN TALKKI OY			
Ore quarried	331,515	338,348	371,305
Talc concentrate	164,126	160,997	181,956
Nickel concentrate	4,256	3,106	3,793
OY LOHJA AB			
Feldspar concentrate	74,089	63,066	69,608
Quartz concentrate	222,974	243,169	234,429
Talc ore quarried	294,490	247,040	181,800
Nickel concentrate	4,205	3,726	2,589
KEMIRA OY			
Ore quarried	1,951,545	2,402,000	2,877,000
Apatite concentrate	131,900	200,927	233,053
Calcite concentrate	8,300	27,037	54,461
LIMESTONE AND CEMENT COMPANIES			
Limestone quarried	5,282,423	4,812,823	5,283,000
Cement produced	1,792,520	1,787,079	1,794,200
Wollastonite concentrate	8,782	13,690	14,962

1. Average Cu-content 1982, 23.9 percent. 2. Average Ni-content 1982, 7.0 percent. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

FRANCE

In 1982 all mining and metallurgical production was below 1981 levels due to the continuing economic depression.

In recent years prospecting efforts for uranium have increased considerably, both in the areas covered by prospecting licenses and the amounts of money spent. However, the overall market situation for uranium is such that expenditures on uranium prospecting were cut by 20 percent last year.

Cogema continued its activities in Limousin, Vendee, and Herault as well as on the Coutras deposit in the Gironde discovered in 1980. Work at Coutras was

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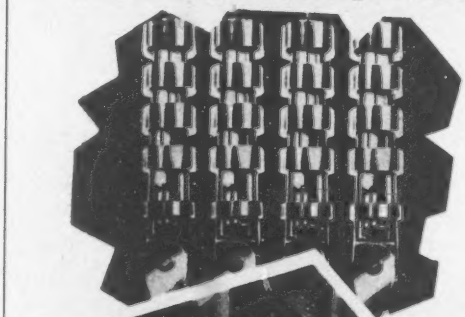

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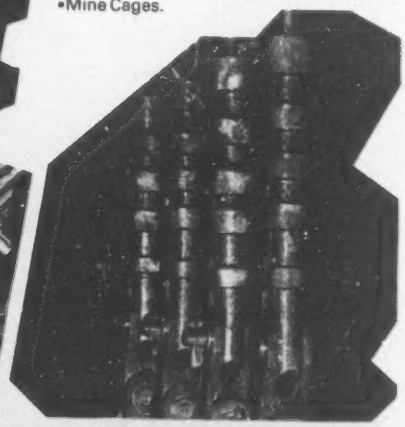

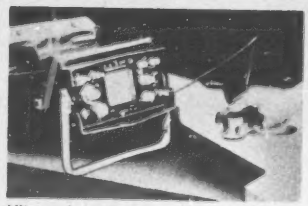

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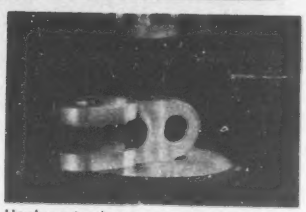

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aimed at getting further knowledge of the deposit which contains 20,000 tons of uranium.

Total French uranium resources are 120,000 tons (metal). In 1982 uranium production was 2,876 tons of uranium contained in concentrates. In addition to domestic ore production, a further 2,925 tons was produced from concentrate imported from Niger and Gabon.

Iron ore production fell from 21,600,000 tons in 1981 to 19,400,000 tons in 1982. The Lorraine mines produced 18,300,000 tons, the mines in the West of France produced 1,000,000 tons, and the Pyrenees mines produced about 100,000 tons. The total ore produced contained 6,100,000 tons of iron which gives an average grade of 31.4 percent.

No iron ore mines were closed down in 1982, but production had to be cut back to adapt to the requirements of the iron and steel industry. Imports of iron ore amounted to 14,900,000 tons compared to 16,500,000 tons in 1981. Of this total 3,800,000 tons came from Brazil, 2,700,000 tons from Sweden, 2,200,000 tons from Mauritania, 1,800,000 tons from Australia and 1,600,000 tons from Liberia. Iron ore exports amounted to 5,500,000 tons of which 5,100,000 tons went to Benelux and 400,000 tons to the Saar region of West Germany.

French mine, smelter, and refinery production of ores, metals, and minerals in metric tons

Commodity	1980	1981	1982
Coal and brown coal	20,700,000	21,500,000	16,900,000
Brown coal only	N.A.	N.A.	3,100,000
Iron ore	29,000,000	21,600,000	19,400,000
Pig iron	19,200,000	17,300,000	15,000,000
Steel ingot	23,200,000	21,100,000	18,400,000
Bauxite (average Al_2O_3 grade 55 percent)	1,892,000	1,828,500	1,700,000
Aluminum metal	432,000	435,580	390,700
Magnesium	9,328	—	—
Silver	248	304	N.A.
Lead concentrate	39,200	26,614	8,600
Lead, refined metal	218,831	228,000	208,600
Zinc concentrate	66,500	67,790	66,900
Zinc, refined metal	252,770	257,130	253,400
Cadmium	789	—	—
Gold[1]	1,100	913	2,100
Copper, refined metal	46,460	47,000	46,200
Nickel, refined metal	9,792	10,050	7,400
Tungsten, metal content	577	744	733
Uranium, metal content	2,600	2,555	2,876
Potash (K_2O content)	1,891,070	1,831,000	1,701,000
Fluorite (average CaF_2 content 80 percent)	276,000	304,000	286,000
Rock salt, untreated	301,200	298,000	382,000
Salt brine	4,415,300	3,870,000	3,711,000
Salt refined	1,112,700	1,092,000	1,071,000
Talc	316,100	280,000	313,000
Sulphur	1,840,000	1,711,000	1,632,000
Barite	215,000	190,000	156,600

1. Kilograms. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

Total pig iron production was 15,000 tons. Of this 6,700,000 tons were from the Eastern region, 4,700,000 tons from the North, and 3,600,000 tons elsewhere. Raw steel production was 18,400,000 tons and exports were 7,510,000 tons while imports were 7,136,000 tons.

As can be seen from the table, both bauxite and aluminum production fell from 1981 to 1982.

Lead and zinc ores continued to be produced in the Saint Salvy (Tarn), Malines (Gard), and Largentiere (Ardeche) mines. However, Largentiere was finally closed during the first half of 1982 because of exhaustion of reserves.

The two tungsten mines of Salau (Ariege) and Montbelleux (Ille et Vilaine) produced 290 tons of concentrate containing 217 tons of WO_3 and 927 tons of low grade concentrate containing 519 tons of WO_3.

The Salsigne gold mine in the department of Aude produced 1,350 kilograms of gold and 3,000 kilograms of silver, 980 tons of copper, and 7,340 tons of arsenic trioxide. The gold mine operated by the Bourneix group in Haute Vienne started up in 1982 and during the year produced 123 kilograms of gold and 345 kilograms of silver.

In the eighth full year of the project to make an inventory of French mineral resources, the improvements in methods which were introduced in 1981 were further pursued with the aim of better refining and selecting the anomalies for investigation. Sums allocated to the Inventory Project increased by 14 percent to 65,700,000 Francs ($9,000,000). A total of more than 450 anomalies were investigated during the year, of which 37 were percussion drilled and 32 core drilled.

One of the main prospects is the Aurieras (Haute Vienne) gold prospect which is close to the Bourneix gold mine and has potential for several tons of metal.

At the Leucamp (Cantal) tungsten prospect a test panel was investigated and the quality of the deposit was confirmed. Beneficiation tests will shortly be undertaken.

At Rouez (Sarthe) the work undertaken with the oil company Société Nationale Elf Aquitaine did not confirm the base metal potential of this massive sulphide body which turns out to be essentially a pyrite deposit with an oxidized gossan which is probably mineable for silver and gold.

GREECE

By **A. Barounis**
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The decrease of production in the Greek mining industry which began in 1980 continued during 1982. The main reasons are the world economic crisis; a decrease in exports to the Eastern bloc countries; and competition in the magnesite sector from Chinese and Korean exports. Exports for the whole year are estimated to have been worth $300,000,000, in contrast to a value of $383,400,000 in 1981 and $458,400,000 in 1980. Mineral exports represented about 12 percent of the country's total exports.

The country is a major European producer of bauxite with annual production around 3,000,000 metric tons per year. The principal producer, Bauxites Parnasse, mines some 1,800,000 tons. However, market problems are causing exports to fall. Despite this, a study is being made of plans to build an alumina refinery in the country. Initial capacity would be 600,000 tons a year, of which over half will be exported to the Soviet Union and other East Bloc countries. In May last year it was announced that Bauxites Parnasse would invest $7,300,000 in 1982 and $10,000,000 in 1983 on infrastructure and new equipment at its mining operation.

A new plant with an annual capacity of 40,000 tons of ferrochrome was completed with technical assistance from Outokumpu in Volos at a cost of $17,000,000. Chromite will be supplied by the Bourinos mine in west Macedonia.

The metallurgical plant and mine of Compagnie Francaise des Mines de Laurium were closed. However a state company, Hellenic Mining and Metallurgical Co. of Laurium, will be formed to reopen the processing plant. Lead concentrate will come from the Stratonian and Olympias mines of the Chaldiki peninsula. The aim is to supply 32,000 tons per year of concentrate to produce 19,000 tons of lead and lead alloys, plus about 55 tons of silver and some bismuth.

The Greek Bank for Industrial Development (ETVA) and the Bodosakis group will construct a new lead and zinc plant in the Nestos area of eastern Macedonia. The plant, which will cost $350,000,000, will have an annual output of 40,000 tons of lead, 40,000 tons of zinc,and 90,000 tons of phosphoric acid. Ore requirements will be 160,000 tons of complex sulphides from the Kassandra mines and 300,000 tons of phosphorus ore.

An asbestos fiber mining complex was started in 1981 at Zidani, near Kozani. It includes a 5,000,000-ton-a-year open pit and a dressing plant capable of producing 100,000 tons of fiber annually. Output was targetted to reach 70 percent of capacity during 1982, but this was not achieved due to weak demand for asbestos.

Uranium exploration in areas of eastern Macedonia continued during 1982. Results were favorable and some economically mineable reserves have been proved. Total exploration during 1982 amounted to 2,726 meters (8,944 feet) of exploration drifting and 281,725 meters

Greek production of ores, minerals, concentrates, and metals in metric tons

Commodity	1980	1981	1982
Bauxite	3,861,800	3,218,200	2,600,000
Nickeliferous iron ore	2,000,000	N.A.	N.A.
Magnesite	1,150,000	961,700	770,000
Mixed sulphide	1,040,000	866,100	700,000
Manganese ore	95,500	79,500	63,700
Chromite concentrate	25,000	20,900	16,700
Chromite, mined	75,000	40,400	70,000
Lignite	27,000,000	27,000,000	27,000,000
Gypsum	450,000	450,000	N. A.
Silica	25,000	25,000	N. A.
Kaolin	45,000	37,400	30,000
Bentonite	320,000	264,000	210,000
Perlite	306,000	254,800	203,000
Aluminum	175,000	146,100	117,000
Alumina	602,000	502,000	400,000
Barite	140,000	116,800	93,000
Lead	14,400	12,000	9,600
Lead concentrates	43,000	35,800	28,000
Magnesite, dead burnt	328,000	273,400	220,600
Nickel, alloy	13,080	10,900	8,700
Pyrite	194,000	162,000	130,000
Zinc concentrate	56,600	47,200	38,000

1. Estimated. N.A. Not available. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

(924,295 feet) of exploration drilling. Total investments in mining during 1982 were $55,000,000.

Greece is now the largest importer of perlite in the world and the third largest exporter of bentonite. A new cement plant went into production for the Heraclis group in the Milaki area of Evboea. Annual capacity is 1,500,000 tons.

There has been an increase in government activity in the mining industry. State contributions to exploration during 1982 amounted to 23 percent. All this was in lignite exploration. Annual lignite production is currently about 27,000,000 tons. The five-year plan of the National Power Corporation provides for an investment of $3,500,000,000 between 1983 and 1987. By that time all oil-fired power production should be phased out. An increase in the contribution of lignite in power production is expected; rising from 56 percent at present to 84 percent in 1987. The remaining power will be generated by hydro-electric plants.

GREENLAND

During 1982 the Black Angel Mine, operated by Greenex A/S, produced 135,195 metric tons of zinc concentrate, and 39,632 tons of lead concentrate. Plans to open a newly delineated ore body for summer season extraction only had to be postponed due to environmental constraints. The company has not obtained permission to discharge an additional 40,000 tons of tailings annually into the fjord. A thorough assessment of the environmental impact of this extra loadhas to be made.

Greenland mineral production and exports in metric tons

Commodity	1980	1981	1982
Cryolite ore	47,000	48,000	46,400
Cryolite concentrate[1]	20,700	17,600	18,800
Lead concentrate	43,200	38,000	39,600
Zinc concentrate	140,500	139,800	135,200

1. Exported from Denmark. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

A/S Kryolitselskabet Oresund slightly increased its sales of refined cryolite compared to 1981. The company obtained permission to reopen its abandoned pit at Ivigtut in order to mine remaining low grade crude ore, which was not considered to be economic when the pit was closed in 1962.

HUNGARY

By **József Molnár**
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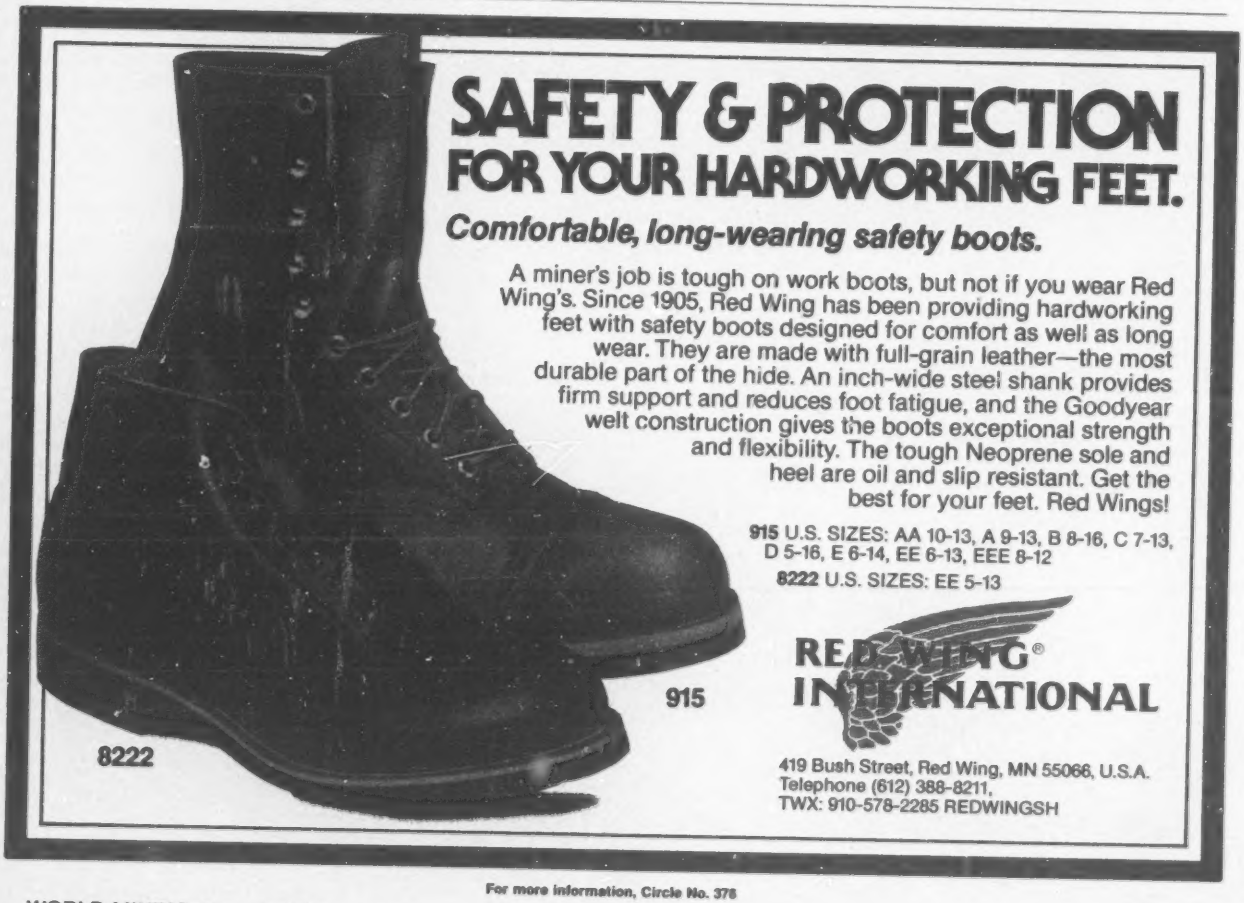
The improvement in the world economy, forecast for 1982, did not take place. As a result many cutbacks had to be made, particularly in energy consumption. A program of substituting coal for hydrocarbons started in previous years.

The price of hydro-carbon products continued to increase and the rate of pro-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gress in some projects slowed down. Under State sponsorship no large project started in 1982 and the same is expected in 1983. Capital allocated for mining projects now in progress were only slightly modified. Thus, in spite of difficulties, the mines produced as planned.

A total of 2,600,000 tons of bauxite was extracted in 1982. Proven bauxite reserves are sufficient for several decades. One third of the production comes from open pit mines, the rest from underground.

Bauxite production is by Fejér megye bauxite mines and Bakony bauxite mines. The latter supplied some 75 percent of total production. As a result of a major investment program new mines and mining areas were developed, Bitó II, Halimba III, Fenyöfö, or are under development. In these improved mining methods with automation have been employed. The development of Bitó II took six years, during which 11,000 meters of development was driven. For 1983 the production target is 400,000 tons of bauxite. At Halimba III ore is delivered to surface through a 1,500 meter long inclined shaft, in which a 1,000-millimeter wide conveyor operates. The Fenyöfö bauxite mine with 650,000 tons per year capacity will be partially in operation in 1984. Most bauxite will be produced underground, the rest from open pit mining.

The alumina plants (Almásfüzitö, Ajka, and Mosonmagyaróvár) supplied 745,000 tons in 1982. A small part was smelted in Hungary while the majority went to the Soviet Union.

In the aluminum industry recessionary tendencies manifested themselves in 1981. Prices dropped suddenly and demand substantially decreased. This continued early in 1982, but at the year's end market interest revived slightly. Low prices on the world market were unfavorable to the Hungarian aluminum industry. To compensate the industry took steps to improve quality and offer more selected products. Aluminum industry export turnover was about $260,000,000.

Hungarian metals and minerals production in metric tons

Commodity	1980	1981	1982
Hard coal	3,065,000	3,065,763	3,038,720
Brown coal	14,156,000	14,463,295	14,753,868
Lignite	8,479,000	8,413,123	8,286,113
Iron ore	426,480	422,475	466,533
Manganese ore,			
oxides	134,000	120,593	149,430
carbonates	472	1,372	605
Lead-zinc ores	145,297	106,863	98,256
Lead concentrate	2,081	937	1,062
Zinc concentrate	5,443	2,680	2,860
Bauxite	2,950,000	2,914,021	2,626,935
Bentonite, raw	72,685	80,531	84,934
Bentonite, processed	N.A.	52,515	54,014
Kaolin, raw	51,839	52,518	45,131
Kaolin, processed	N.A.	7,024	7,109
Perlite, raw	99,270	95,190	89,975
Glass sand, raw	713,136	777,480	680,968
Foundry sand	N.A.	691,579	585,075
Alumina	811,216	799,142	744,964
Crude aluminum	73,497	N.A	N.A.
Aluminum semi-products	143,000	143,000	150,000
Pig iron	2,214,000	2,193,000	2,183,320
Crude steel	3,763,000	3,600,000	3,651,714
Cement	4,660,000	4,600,000	4,369,000

N.A. Not Available. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric ton.

Siderite, produced at Rudabánya in 1982, could only cover a small proportion of the country's iron ore requirements. THe balance was mainly supplied from the Soviet Union, with some from the West. Siderite production was 466,000 tons.

The three steel plants (Dunaujváros, Diósgyör, and Ozd) produced 2,200,000 tons of pig iron, 3,600,000 tons of crude steel and 2,860,000 tons of rolled steel. The industry produces to export, in addition to covering the country's need. The effect of the recession was that export possibilities fell substantially. To step up the export capacity a program of modernization was implemented. The industry is now able to mass produce high grade stell alloys. At Diósgyör, a continuously operated steel foundry was put into service. A new computer controlled converter steel making plant at Dunaujváros can supply about 150 tons per hour of hih quality steel.

At Urkut manganese mine 149,000 tons of oxide ore were mined. Were the available capacity better utilized both home and export demands could be met.

Development of the new mine at Recsk, with 150,000,000 tons of ore in reserve, slowed down for economic reasons. Since the older ore deposits are depleted and the new mine is still not operating, at present no copper ore is produced in the country.

Gyöngyösoroszi mine supplied 98,000 tons of lead and zinc ores in 1982. Its ore reserves are near to depletion. Exploration has not shown substantial new reserves up to now. The mine's dressing plnat produced 1,000 tons of lead and 2,860 tons of zinc concentrates.

Pálháza perlite mine produced 89,000 tons in 1982. Most of the product was exported. Other important minerals to be found in the Tokaj Mountains are, bentonite, kaolin, diatomaceous earth and zeolite. The production mainly met domestic needs. At Kisörs in Transdanubia 585,000 tons of foundry sand and at Fehérvárcsurgó mine 681,000 tons of glass sand were produced. Production of gravel, marl, limestone, ornamental stone amounted to 80,000,000 tons. Cement production was 4,400,000 tons in 1982. The amount consumed exceeded slightly that produced in Hungary.

IRELAND

The year 1982 was one of deepening recession and continuing difficulty for the mining industry. Ore reserves at the lead-zinc mine at Silvermines, County Tipperary were exhausted in July and the mine has closed. Some 345,000 tons of ore with a combined grade of 9 percent were milled in 1982. Avoca copper mines also ceased production in June following termination of State aid. However, Tara Mines Ltd. settled a prolonged labor dispute and production recommenced in February.

Some 1,500,000 tons of ore grading 11.3 percent combined metal was milled during the year and 151,000 tons of zinc and 27,000 tons of lead in concentrates produced. The company recorded a profit from operations of $700,000. Reserves at December 1982 amounted to 53,000,000 tons of 12.1 percent combined zinc-lead, and the State Mining Lease area was extended during the year. Development of the Bula Ltd. part of the ore body has not yet commenced and although progress was made in obtaining Planning Permission the company is still facing difficulties.

Mineral exploration during 1982 also reflected the recessionary trend, with some 500 exploration licenses current at the end of the year compared to the peak of 924 in 1974. Nonetheless, some 40 companies were still involved in exploration, either on their own or through joint venture agreements, and total expenditure in 1982 was about $7,000,000.

No new prospects have been announced and the general exploration trend in the carbonate hosted terrain was again for more intensive effort of the more promising prospects and areas of sub-economic mineralization. Interest was maintained in the Lower Palaeozoic rocks of south-east Ireland and the Longford-Down Massif, (where Anglo United is continuing its detailed work on a gold prospect near Clontibret), and particularly in the metasedimentary Dalradian rocks in County Donegal, where the potential for a diversity of metals has long been known.

A variety of projects and background studies are being carried out by the Geological Survey of Ireland, some with EEC aid, in order to focus attention on relatively neglected areas as well as diversifying exploration interest. In addition, the way was cleared for the State to make available, during 1983, large amounts of exploration data on surrendered licences that had previously been held on a confidential basis.

Magcobar Ltd.'s production of about 240,000 tons of barite from its mine at Silvermines, Co. Tipperary held Ireland's output at comparable levels to 1981 in spite of the suspension of production at Milchem Ltd.'s tailings recovery operation at Tynagh, County Galway and the closure of its mine at Duneen Bay, County Cork. It is hoped that the latter will, following efforts by the State, reopen in 1983 under new management.

Some 371,000 tons of gypsum were produced by Gypsum Industries Ltd. from two mines near Kingscourt, County Cavan. Cement production was again

Irish mineral production in metric tons

Commodity	1980	1981	1982[1]
Anthracite & semi-bituminous coal	63,471	70,400	82,750
Barite	259,947	273,939	265,814
Cement	1,898,460	1,937,600	1,580,000
Copper[2]	4,178	3,389	1,573
Gypsum	381,536	358,842	371,040
Lead[2]	58,905	30,500	39,000
Pyrite	25,000	22,600	13,800
Silver[3]	771,089	1,104,000	351,980
Zinc[2]	228,713	120,300	167,178

1. Provisional figures. 2. Metals in concentrates. 3. Ounces. 1.0 metric ton = 1.10 short tons. 1.0 short ton = 0.907 metric ton.

curtailed by the current cut-back in the construction industry, but Irish Cement Ltd. continued with the conversion of its plant at Limerick to a coal burning dry process. This is due to be completed this year, when the company will have a production capacity to 2,500,000 tons per annum.

Bechtel Corp completed construction of the country's first alumina refinery. The $1,000,000,000 plant will produce some 800,000 tons of alumina each year. The capacity can be expanded to 2,400,000 tons a year. It is situated on the island of Aughinish in the Shannon estuary. The operating company is Aughinish Alumina Ltd., 40-percent owned by Aluminium Co of Canada Ltd., 35 percent by Billiton Aluminum Ireland Ltd., and 25 percent by Anaconda Ireland Co. Initially high quality bauxite from Boké in Guinea and from Brazil will be used although it has been designed to accomodate lower quality feed. The alumina is primarily to be exported to smelters in Europe.

ITALY

The downward trend that has characterized the industry for some time does not show any sign of improvement, as shown by the production table.

Lead and zinc production has been severely affected by the closing of some mines and the continuing depletion of others. During 1982, Mineraria Pertusola reopened the Salafossa mine which had been closed halfway through 1980 because of a landslide that put the treatment plant out of operation. However, reserves are nearing exhaustion and the mine will go out of production completely in a few years.

Investigations by drifting and exploration drilling are being carried out to determine the limits of the Raibl mine ore body. Similar work is progressing at the Montevecchio and Monteponi mines in south west Sardinia. The output of galena, mined with fluorite, at the Silius mine maintained previous levels.

The Masua mine (World Mining, January 1982, pages 36 to 39) has maintained production levels of previous years, but has still failed to reach maximum capacity due to technical problems. Development was carried out to extend the depth of the workings.

Development of the Funtana Raminosa (Pb, Zn, and Cu) mine was completed as well as construction of the treatment plant and the main surface infrastructure. Mining started towards the end of the year and the treatment plant was commissioned. Geological work has suggested that the ore is very unevenly distributed throughout the main ore body and therefore alternative mining methods to sub level stoping are being investigated to achieve higher selectivity.

Development of the Fenice Capanne (Pb, Zn, and Cu) mine continues. Mining of the spiral decline and the main haulage has almost been completed. Surface facilities such as workshops, the treatment plant, and the transformer room are also nearly complete. Preliminary investigations of the cement fill are well underway and production should begin during 1983.

Production of iron ore, that has been steadily falling, will cease altogether during 1983 when the mines on the Isle of Elba are closed down.

The antimony production rate reflects the gradual depletion of the Manciano deposits. Moreover, about 84 percent of the output has had to be stockpiled because the smelters have cut down on their consumption of concentrate. The fall in mercury production for 1982, from Mount Amiata mine, reflects the shrinking domestic demand.

Samim's exploration program has finished reasonably successfully. Other exploration under the same contract will be continuing, and results appear encouraging so far.

Output variations of other minerals appear to be related to commercial factors depending on the economic situation, rather than any technical problems.

Act No. 752, approved by government in October 1982, was an important event. Aimed at stimulating a revitalization of the mining industry its covers regulations and incentives to stimulate exploration throughout the country and on the continental shelf. A total of more than $268,000,000 has been allocated to implement a number of programs within the planned development of the mining industry.

LUXEMBOURG

No iron ore production took place in Luxembourg in 1982, it ceased in November 1981.

Iron ore imports decreased from 6,275,192 tons in 1981 to 6,159,656 last year. The quantity of ore imported from France rose from 4,522,073 tons in 1981 to 4,738,948 in 1982. A total of 1,420,708 tons were imported from Brazil, Sweden, and South Africa, as compared to

Italian production of metals and minerals in metric tons

Commodity	1980	1981	1982
Antimony ore	1,420	1,323598	
Iron ore	184,733	123,4073,093	
Lead concentrate (64 percent Pb)	28,941	21,030	14,025
Zinc concentrate (54 percent Zn)	79,190	43,785	40,270
Zinc concentrate (8 percent Zn)	69,188	65,685	16,540
Pyrite	858,992	681,000	666,680
Asbestos	157,794	137,086	116,400
Barite	203,038	177,005	180,020
Fluorspar	151,965	164,235	166,950
Feldspar	344,301	428,485	783,410
Talc	165,905	163,706	163,770
Salt	3,997,096	3,610,619	2,604,580
Potash salts	1,301,649	1,417,800	1,460,230
Sulphur ore	100,852	96,202	88,850
Bentonite	332,888	277,350	237,330
Marble	4,000,000	5,500,000	4,800,000
Lignite (20 percent H_2O)	1,932,571	1,957,980	1,912,675
Aluminum, metal	271,199	269,495231,755	
Antimony	676	792963	
Lead, metal	47,251	35,560	36,900
Zinc, metal	206,430	190,903	158,560
Cadmium	568	482	515
Silver, metal	36	5556	
Mercury	3	252159	

1.0 short ton=0.907 metric ton. 1.0 metric ton=1.10 short tons.

1,753,119 tons in 1981.

In 1982 steel production was 280,150 tons or 7.39 percent less, dropping from 3,790,000 tons in 1981 to 3,509,850 tons in 1982. There was a drop also in pig iron production at 2,586,820 tons, 302,500 tons less than the year before.

The number of workers in the steel industry dropped to 13,273 from 14,127 in 1981 and from 3,841 to 4,006 employees.

Luxembourg production of iron ore and steel, and imports of iron ore in metric tons

Commodity	1980	1981	1982
Iron ore production	560,165	429,000	—
Iron ore imports	7,872,580	6,275,192	6,159,656
Steel production	4,818,650	3,790,000	3,509,850

1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

NORWAY

Today, with more optimism in the world economy, it is hoped that 1982 is the last of a series of difficult years for the mining industry in Norway. Several of the mining companies, mainly in iron ore, had to reduce their production last year because of the market situation. Hardest hit was Sydvaranger which reduced production of pellets by 27 percent compared to the 1981.

In accordance with a government decision in 1981, the State owned A/S Sydvaranger formed two new companies last year. One is a holding company for Sydvaranger's many side activities, sulphide mines, quartz mines, etc. The second includes the company's ore prospecting di-

vision. While some of the parts of the holding company will probably be sold, A/S Sydvaranger is concentrating on its iron ore operations in Kirkenes.

The mining rights of Sulitjelma Gruber, a copper/zinc mine north in Norway, expire in July 1983. The owner, Elkem, does not want to continue the operation after that date. The operation has resulted in high losses the last few years. The government has guaranteed continuation of the operation and tried to find other companies willing to take over the mine. To handle the transfer of the mine and secure a continuous operation, a state-owned company, Sulitjelma Bergverk, has been formed.

AMMC, of the United States, has taken over 50 percent of Orkla Industrier's ferroalloy division. Cooperation between the two companies has existed for a long time. Through its subsidiary, Metall und Rohstoff of West Germany, AMMC has, since 1967, been responsible for sales and marketing of Orkla's ferroalloy products.

The Government owned DNN, Tyssedal, has decided to stop production of aluminum. Last spring parliament voted for a proposal to rebuild the smelter to produce titanium slag. Ilmenite concentrates from the Norwegian mining company Titania A/S is an alternate raw material for the plant. Elkem was granted a contract to prepare a feasibility study. In the spring session of 1983 parliament debated possible funding of the project.

Norwegian mine and smelter production in metric tons

Commodity	1980[1]	1981[1]	1982[2]
Iron concentrate[3]	3,883,600	4,137,680	3,265,800
Ilmenite concentrate[4]	827,827	659,604	551,800
Pyrite concentrate[5]	421,357	435,493	423,000
Copper concentrate[6]	113,857	110,550	108,300
Zinc concentrate[7]	51,955	56,379	60,900
Lead concentrate[8]	4,467	5,531	6,790
Nickel concentrate[9]	12,090	12,000	9,700
Graphite concentrate	10,406	6,884	10,200
Coal	289,412	439,729	335,500
Feldspar	67,559	N.A.	N.A.
Nepheline syenite	231,339	216,885	212,500
Limestone	4,146,395	3,832,356	N.A.
Dolomite	559,117	457,8080	N.A.
Quartz	843,762	633,222	N.A.
Olivine	1,101,739	1,340,668	N.A.
Fillers	204,579	171,302	N.A.
Cement	2,206,000	1,837,000	1,705,400
Silicon carbide	58,901	55,464	53,900
Calcium carbide	89,579	78,979	76,500
Pig iron	611,680	586,584	483,500
Steel ingots	854,125	862,449	768,000
Ferrosilicon[10]	319,983	313,736	260,100
Other ferroalloys[11]	494,720	464,876	405,300
Aluminium	653,377	633,585	636,900
Magnesium	44,352	47,455	35,900
Copper metal	33,690	31,951	24,400
Nickel metal	37,123	36,954	25,600
Cobalt	1,275	1,444	1,000
Zinc metal	79,416	80,279	78,700
Cadmium	130	117	100

1. Official figures. 2. Preliminary figures. 3. 64.3 percent Fe. 4. 44.5 percent TiO_2. 5. 50 percent S. 6. 25.3 percent Cu. 7. 52.7 percent Zn. 8. 57.5 percent Pb. 9. 4.0 percent Ni. 10. 75 percent Si. 11. Ferrochrome, ferromanganese, ferrosiliconmanganese, ferrosilicon-chrome, others. N.A. not available. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

POLAND

There was a slow return to the pre-crisis output of main metals in Poland. Cathode copper production is again close to the record production of 1980 and further increases may be expected. Prospecting continued with good results in the area along the Fore-Sudetic block and especially in the Kozuckow area. However, any start up of new prospects and mine development was postponed.

Prospecting for zinc and lead ores in the Upper Silesia and adjacent area stagnated. Zinc metal production has now fallen by tens of thousands of tons as imported ores are now scarce.

Skawrna aluminum smelter situated very near to the city of Cracow, with a population of almost 1,000,000, was closed respecting for the first time the requirements for environmental protection raised by striking workers. As a result Polish aluminum production has fallen by a half.

The crisis due to the troubles in 1981 caused a 15 percent fall in coal production from 193,000,000 to 163,000,000 tons and affected all industrial users of electricity. This crisis has passed and the main mine production returns to normal.

For more information, Circle No. 378

Polish production of metals and minerals in metric tons

Commodity	1980	1981	1982
Coal, bituminous	193,000,000	163,000,000	189,300,000
Coal, lignite	36,900,000	35,600,000	37,600,000
Zinc and lead (net ores)	5,510,000	5,035,000	N.A.
Pig iron	11,953,000	9,351,000	N.A.
Rock salt	4,534,000	4,273,000	N.A.
Copper (wet ore)	26,568,000	22,819,000	N.A.
Steel	19,485,000	15,719,000	14,500,000
Zinc metal	215,000	167,000	165,400
Lead metal, refined	82,000	69,000	78,800
Lime	4,850,000	4,179,000	N.A.
Copper metal cathodes	357,000	327,000	348,000
Silver	766	640	N.A.
Aluminum	95,100	66,000	42,700
Sulphur	5,185,000	4,773,000	4,920,000
Cement	18,400,000	14,200,000	N.A.

According to Polish Main Statistical Office. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

Marshal law, military supervision of the coal mines in the Upper Silesian district and high extra payments for miners for Saturday and Sunday working brought this production almost back to the level of 1980. The growing production of the new Bohdanke coal mine in the coal district situated east of Lublin also contributed to the surprisingly smooth return to normal output.

However, production of major electricity users such as the steel and cement industries was still lower than the 1980 record year. Also cement and lime production was reduced paralel with the decline in coal and subsequent electricity production, and now slowly returns to previous levels.

PORTUGAL

The statistics for 1982 generally compare unfavorably with those of 1981. In fact, with the exception of tin, gold and silver, titanium, uranium and salt, most mineral production fell significantly. The world recession and some domestic difficulties were responsible for the drop in some production levels and for the lack of expansion in others.

Tungsten mining was obviously hit by the continuous drop in market prices in 1982. The largest mine kept production at the same level as 1981, a year in which operations were hampered by industrial action. All other mines had a very difficult time in 1982.

The work on the Neves Corvo copper deposit, near Castro Verde, proceeded during the year, with prospecting and development activities. A total of more than 20,000 meters of diamond drilling was carried out, including prospecting work carried out over the areas around the main zone. Development of the vertical shaft and access ramp progressed well, the first now about 200 meters below shaft collar and the second with an advance of nearly 900 meters.

All the technical work for the economic feasibility study is now near completion as the preliminary engineering of the project for underground mining, treatment plant, and infrastructure has been carried out by various engineering firms.

Portuguese metal and mineral production in metric tons

Commodity	1980	1981	1982[1]
Anthracite	177,453	183,760	178,540
Ferro-manganese	41,850	37,050	27,100
Copper concentrate	3,009	2,437	2,002
Tin concentrate	391	506	531
Gold and silver (sulphide) concentrates	1,505	1,123	1,501
Niobium and Tantalite	4	9	6
Titanium concentrate	234	400	472
Tungsten concentrate	2,654	2,342	N.A.
Barite	1,200	1,350	500
Diatomite	2,310	2,690	1,770
Feldspar	40,802	44,007	41,223
Cupriferous pyrite	387,170	286,622	263,142
Quartz	124,538	120,850	104,234
Salt	401,276	406,146	406,255
Talc	2,598	3,512	2,876
Uranium	95	120	132
Washed kaoline	49,724	51,030	50,617
Rico-washed kaoline	12,455	29,313	12,414

1. Provisional figures. 1.0 short tons = 0.907. 1.0 metric ton = 1.10 short tons.

SPAIN

Depressed metal markets and three years of severe drought in central and southern Spain have made it difficult for the mining industry, especially in te production of lead, silver, and zinc. The 1,000,000-ton-per-year Aznacollar pyrite mine of Andaluza de Piritas S. A. remained closed for the entire year and, as a result, lead and zinc concentrate production were at lower levels. Operations have since resumed at Aznacollar after Piritas de Andaluza signed a new sales contract with a United States firm a few months ago.

Potash producers had a difficult period. Potasas de Navarra S. A. may be closed down due to its unsuccessful exploration program and high production costs. Despite the difficult times, the state-owned company Fodina is expected to carry out extensive exploration to delineate additional ore reserves in Catalonia. Fodina acquired Solvay's interest in Minas de Potasa de Suria.

Adaro and Eniter examined lead-zinc-silver prospects near Mazaron on the southeast coast—a region that was mined some 2,000 years ago. Company officials feel that remaining reserves could be mined profitably with modern mining methods. Some initial samples from the exploration effort graded 2 percent lead, 3 percent zinc, and about 20 ounces per ton silver.

Projects under development included the Minas de Almagrera S. A.'s sulphide mine at Sotiel—the operation is expected to produce at a rate of about 5,000 tons of contained lead, 20,000 tons of contained zinc, and 2,000 tons of contained copper in concentrates per year—and the expansion of Agruminsa's iron ore operations in Gallarta.

Generally, production decreased for all minerals with the exception of metallurgical grade fluorite, calcic magnesite, and meerschaum. Mercury output remained at the same level as in the preceding year.

SWEDEN

By **Sven-Gunnar Bergdahl**
Managing Director
Swedish Mining Association
Stockholm

Production from the Swedish iron ore mines decreased by about 30 percent during 1982, while production of sulphide ores increased about 7 percent. The total of iron ore products and processed sulphide ores was 31,700,000 tons compared with 37,800,000 tons in 1981. The record year was 1974 with 47,300,000 tons. At the beginning of the year, there were six producing mining companies.

Exports of iron ore during 1982 were nearly down to the 1949 level. At the end of the year, stocks amounted to about 11,100,000 tons, an increase of about 400,000 tons during the year. Deliveries amounted to 15,300,000 tons compared with 20,100,000 tons in 1981. Domestic deliveries were 2,400,000 tons. The Lapland mines accounted for 91 percent of export and 61 percent of domestic deliveries.

Production of sulphide ores was 15,600,000 tons an increase over the 1981 output of 14,600,000 tons.

Deliveries of about 13,000,000 tons forced Luossovaara Kiirunavaara AB (LKAB) to reduce production considerably. Production was stopped for a total of 15 weeks at Kiruna, 13 weeks at Svappavaara and 10 weeks at Malmberget.

The new pelletizing plant at Kiruna was run during the year with good results. Total capacity of the three pelletizing plants within LKAB is now 9,000,000

Swedish mineral production in metric tons

Commodity	1980	1981	1982[1]
Iron ore products	27,184,000	23,225,000	16,138,000
Pyrite concentrate	396,000	421,000	426,000
Copper concentrate	181,000	222,000	235,000
Lead concentrate	102,000	123,000	120,000
Zinc concentrate	306,000	334,000	346,000
Cement	2,438,000	2,320,000	2,302,000
Talc	3,000	4,000	4,000
Apatite	88,000	124,000	128,000
Scheelite	600	700	500

1. Preliminary figures. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric ton.

tons per year. During 1982 only 40 percent of that capacity was utilized.

Tests with a modified sublevel caving method in Kiruna have indicated a much lower waste rock dilution than for conventional sublevel caving. The new haulage level in Kiruna, Kuj 75, is now about 80-percent installed. The system has given very good results. It is based on remote-controlled chute operation, automatic sampling, computer-controlled driverless trains and one-stage crushing.

At SSAB's Grängesberg mine 75-percent capacity was utilized, giving 1,500,000 tons of iron ore products (1,000,000 tons concentrate, 330,000 tons granules). Also 86,000 tons of apatite concentrate was produced. In order to reduce stocks, production was stopped for 20 days in the fourth quarter of the year.

At Dannemora about 75 percent of capacity was utilized during 1982 and this is expected to be the level for 1983. Stocks were reduced by reduced working during the fourth quarter of the year. A remarkable blast was fired in October 1982. A pillar, containing 265,000 tons of ore, was blasted with 37 tons of explosive, charged into 1,555 drill holes. The result was very good, with negligible ground vibrations. During 1982, 360,000 tons of iron ore products were produced. Deliveries amounted to 440,000 tons.

Boliden Mineral AB achieved an all-time high of 14,600,000 tons of ore mined and processed by the company's 15 mines, an increase of 8 percent over 1981.

At Aitik, capacity has been increased by 3,000,000 tons per year. Previous technical problems have been solved and plants are now operating satisfactorily.

It has been decided to resume operation of Svärdsjögruvan, 20 kilometers north-east of Falun. This mine was closed in the early 1970's since the deposit was mined out, but prospecting has revealed more ore at depth. The Vassbo mine is depleted and operations have ceased. The concentrator has been put on a care and maintenance basis, pending results of prospecting in the nearby Foskros area.

Intensified prospecting is taking place in the Stekenjokk area as well as in the Skellefte Field and at the Dammsjö silver prospect at Garpenberg.

Beneficiation tests are underway to extract industrial minerals, mainly mica, from tailings at the Aitik mine. Total investments in Boliden's different plants amounted to about $22,000,000.

Production of iron ore, concentrate, and pellets by Luossavaara-Kiirunavaara AB in metric tons

Mine	1980	1981	1982
Kiruna			
Ore	13,330,000	12,000,000	7,500,000
Pellets	1,240,000	300,000	1,000,000
Total	14,570,000	12,300,000	8,500,000
Malmberget			
Concentrate	3,540,000	4,100,000	2,300,000
Pellets	2,590,000	1,700,000	1,700,000
Total	6,130,000	5,800,000	4,000,000
Svappavaara			
Ore	600	100,000	—
Pellets	2,430,000	2,100,000	1,200,000
Total	3,030,000	2,200,000	1,200,000

1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

LKAB's Viscaria plant was commissioned and the first delivery of copper concentrate took place in early November 1982. In mid-1983, full production is planned with 85,000 tons of copper concentrate (25 percent Cu) from 1,000,000 tons of ore.

Stora Kopparberg's underground production in 1982 was 177,000 tons and from 1984 all production, 200,000 tons per year, will be underground. Diamond drilling down to about 1,100 meters has given encouraging results and further prospecting will be carried out.

Vieille Montagne has intensified prospecting and geological activities in order to reduce waste rock dilution. Results are very positive, headgrade of the zinc ore has risen from 8.35 to 8.85 percent. A completely new ventilation system has been installed. It comprises raises, fans and a 20-square-meter ventilation shaft from surface to the 660-meter level. In the concentrator, all de-watering of lead and zinc concentrates is carried out with press filters. This technique is advantageous, economically as well as environmentally. Tests with re-circulation of process water have been successful. The company plans to continue expansion during 1983 with a 10 percent increase of concentrate production. Planned ore production for 1983 is 625,000 tons.

UNITED KINGDOM

The tin mining industry was affected by considerable fluctuations in the price per ton of the metal which varied from a low £6,000 to a high of £9,000 ($9,000 to $14,000) early in 1983. Production was also at a high level being 3,898 metric tons of tin in 1981 and 4,108 in 1982, the highest for 66 years. In addition 726 tons of copper, 10,186 tons of zinc, and 3,044 kilograms of silver were produced.

A major event in the tin sector was the takeover of South Crofty mine by Charter Consolidated and the Rio Tinto-Zinc Corporation which took place in

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August, Charter having a 60-percent interest. Early in the New Year, part of the timber lining of Robinsons' shaft at South Crofty mine broke away and partly choked the shaft. There were no casualities but repair work was considerable.

Geevor Tin Mines plc was unable to pay any dividend although the financial position improved compared with the previous year. A record 194,383 tons were treated in the year including some dump material. Operating costs fell from $38.00 per ton treated in 1980/81 to £34.30 in 1981/82. Recovery was 6.66 kilograms of black tin (65 percent tin metal) per ton of ore treated, falling appreciably from 7.71 in the previous year. A total of 1,295 tons of concentrate was produced, compared with 1,254 tons in 1981. Development at 3,400 meters was lower than in the previous year. Ore reserves improved, however, by 46,716 tons to 433,839 with a slight fall in grade. Consideration is being given to the need to deepen the sub-incline for access in the deeper working in Levant and to examine Botallack which may necessitate reopening Allen's shaft.

The Wheal Jane tin mine, of Carnon Consolidated Tin Mines Ltd., is now a story of continuing, if slow, success. In 1981 it broke even, last year the mine showed a satisfactory profit. As a result, Carnon is seeking permission to explore for further tin ore in an area of about 810 hectares (2,000 acres) at United Downs, another old mining area to the west of the current Wheal Jane workings. The program would include a decline from surface to meet the 240-meter (790-foot) level being driven from the Mount Wellington section of the mine. In addition, the company wants to retreat about 1,500,000 tons of tailings to recover residual tin. Wheal Jane is producing some 1,700 metric tons of tin per year at the moment. If all these plans come to fruition, output could increase to close to 3,000 tons.

Carnon is carrying out some major cleaning-up operations in the County Adit and has already reduced the influx of water from one valley. The adit drains a large area around Wheal Jane, Mount Wellington, and other areas in the United district, as well as Wheal Busy and Killifreth areas.

Wheal Concorde the small underground mine which was started up at Blackwater, north of Redruth, has closed. Since opening 18 months ago, the mine has produced 16,000 tons of ore at 1.12 percent Sn which was treated, on a custom mill basis, at Wheal Jane.

South West Consolidated Resources continued drilling at Redmoor, near Callinton, and reported a significantly increased average grade of tin and wolfram. The ore reserves have been estimated at 44,000,000 tons.

Billiton has withdrawn from its proposed operations in the Restronguet Creck due, it is said, to difficulties over mineral rights. Permission has been given for a scheme to dredge tin-bearing material from the sea bed off the Cornish coast with a treatment plant near Hayle. Production is planned at 50,000 tons per year of 1 percent rougher concentrate which presumably will be brought ashore for final treatment.

A new company is planning to mine baryte near Strontian on Lock Sunart in Scotland. Production of some 30,000 to 35,000 tons per year is planned, plus some lead-zinc ore.

WEST GERMANY

At mid-year and particularly in the second half of 1982 the recession deepened in Germany as in other industrial countries. Production figures were down on the previous year's levels in almost all sectors and new order intake registered further declines due primarily to a stronger fall-off in foreign orders from mid-year onwards. As the last quarter brought no recovery either, gross national product was 1 percent lower than in 1981. This development resulted in the largest wave of business failures in the history of the Federal Republic and the highest unemployment since the 1950's.

Refined metal production decreased

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West German mine production of ores and metals in metric tons

Commodity	1980	1981	1982
Lead ore[1]	31,300	29,000	29,600
Zinc ore[1]	120,800	110,700	105,800
Copper ore[1]	2,600	2,500	2,500
Silver in ore[1]	37.7	39.3	N.A.
Pyrite[2]	222,005	200,000	214,000
Iron ore, crude weight	1,945,000	1,572,000	1,312,000
Iron ore, iron content	597,000	477,000	386,000
Potash salts, crude weight	29,317,000	28,192,000	22,536,000
Potash salts, K_2O content	3,307,000	3,142,000	2,497,000
Salt, (rock and evaporated)[3]	12,289,000	13,375,000	12,041,000
Graphite[4]	11,300	10,400	10,800
Fluorspar	78,000	71,600	75,000
Barite	186,000	177,000	178,000
Coal			
Anthracite and bituminous	87,100,000	95,500,000	96,300,000
Brown coal	129,862,000	130,600,000	127,400,000
Cement	33,135,000	30,207,000	27,771,000

1. Recoverable metal content. 2. Sulphur content. 3. Including NaCl. 4. Including imported graphite, unwrought. 5. Preliminary. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

by 30,000 tons to 1,805,400 tons, 1.6 percent, while consumption of the principal non-ferrous metals, such as aluminum, copper, lead, zinc, nickel, and tin decreased by 1.8 percent or 47,000 tons to 2,500,400 tons.

The greatest drop in production was recorded by the zinc smelters. The volume of production slumped by 8.5 percent or 31,000 tons. Output from the three lead-zinc mines at Rammelsberg, Bad Grund and Meggen amounted to 135,400 tons metal content, marginally more than the previous year. Output from smelters during the year amounted to 350,500 tons lead, an increase of 22,000 tons and 335,000 tons zinc. The production of refined copper increased slightly from 387,400 tons to 394,100 tons.

Owing to totally inadequate levels of activity in several key sectors, the aluminum industry too did not remain unscathed by the long period of economic stagnation. Consumption of primary aluminum in the West Germany in 1982 was roughly at the same level as the previous year at 1,017,000 tons, while the production of primary aluminum, at 722,800 tons, was only 0.9 percent less than in 1981. The domestic smelters still operated at 96-percent capacity on average over the year. Plant operating rates only fell in the last quarter as a result of production cutbacks.

West German smelter production in metric tons

Commodity	1980	1981	1982
Aluminum	730,700	728,900	722,800
Lead (refined)[1]	350,300	348,300	350,500
Copper (refined)	373,800	387,400	394,100
Zinc (excluding dust)	365,200	366,100	335,000
Tin (unalloyed)	2,200	1,800	600
Tin alloys	3,200	2,900	2,400
Solder	17,100	16,700	16,000
Cadmium	1,200	1,200	1,000
Silver	758	657	N.A.
Gold	9.3	8.6	N.A.
Pig iron	33,873,000	31,876,000	27,621,000
Steel ingots and castings	43,838,000	41,610,000	35,880,000

1. Including secondary antimonial lead. N. A. Not available. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

Vereinigte Aluminum-Werke AG idled about 33,000 tons of primary capacity at its 80,000-ton Innwerk aluminum smelter from September 1, 1982. The cutback, blamed on weak demand and rising inventories, lasted until early 1983.

MIM Holdings of Australia acquired a 50-percent share in a German electrolytic zinc plant and a one-third interest in a zinc products plant. The two plants are owned by Metallgesellschaft AG and are located in the Ruhr at Datteln. MIM needed to diversify its markets for zinc concentrate and to secure longer-term contracts.

YUGOSLAVIA

Yugoslav bauxite production accounts for up to 27 percent, copper ore up to 15 percent, lead ore up to 22 percent, and zinc ore up to 9 percent of all European production. However, almost no geological research has been carried out during recent years and that work that has been done is not expected to give more than modest results.

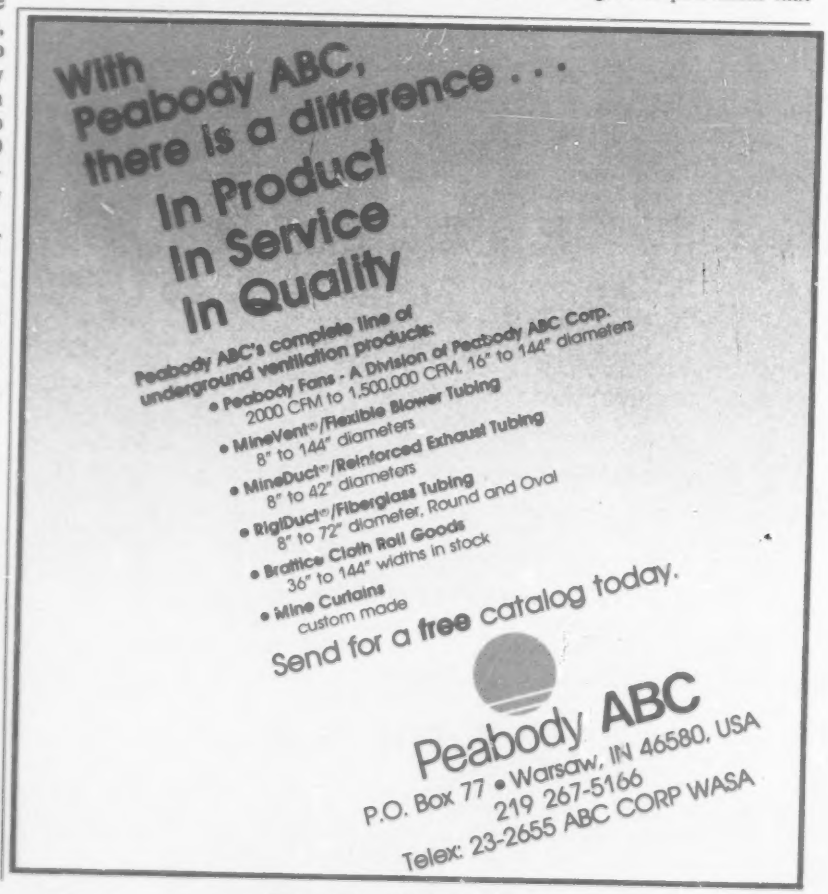
According to plan, some 3,700,000 metric tons of bauxite were mined in 1982 and about 300,000 tons of bauxite with a high silica content was imported. Alumina production was 1,150,000 tons, satisfying domestic requirements for aluminum smelting of about 600,000 tons of alumina. About 700,000 tons of alumina were exported. Consumption of aluminum is about 220,000 tons. Production in 1982 amounted to 260,000 tons but essential aluminum exports (for debt repayments), which will be in force until 1994, rose to 135,000 tons in 1982. Yugoslavia imported about 100,000 tons of aluminum in 1982. It seems unlikely that the production of primary aluminum will reach 440,000 tons in 1985 as planned.

Plans for lead production in 1982, to reach 180,000 tons of lead, were not fulfilled. Domestic need was up to 135,000 tons. Contract and debt-repayment exports were 25,000 tons and imports rose to 40,000 tons.

Some years ago it was possible to recover 100,000 tons of copper from 15,000,000 tons of ore. In 1982 it was only possible to produce 90,000 tons of copper from 20,000,000 tons of ore. Planned 1982 production was 136,000 tons and because consumption is 170,000 tons annually, concentrate is imported.

Zinc production amounted to 98,500 tons, while consumption is just over 90,000 tons annually. Because annual planned exports rose to 32,000, it was necessary to import extra concentrate.

There is a degree of pessimism that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plans for 1985 will not be fulfilled due to insufficient proven reserves and capital. According to the plan, bauxite production should reach 5,000,000 tons, copper ore 33,000,000 tons, lead and zinc ore 6,500,000 tons and antimony ore 320,000 tons. From this output aluminum production should be 440,000 tons, copper production about 210,000 tons, lead production 200,000 tons, and zinc production 180,000 tons. Investments required are $135,000,000 in the aluminum industry, in copper at least $160,000,000, and in lead and zinc about $120,000,000.

Exploration for bauxite has been at a low level. New alumina plants that have been built will require a 40-percent increase in bauxite production during 1985. Record production, in 1979, reached 3,000,000 tons. About 4,200,000 tons will have to be mined in 1985, not including the amount required for exports. It is estimated that exploration will require, up to 1985, an investment of approximately $40,000,000, almost three times the current rate of investment in bauxite exploration. About half of all Yugoslav bauxite reserves are in Bosnia and Hercegovina, a quarter in Monte Negro, and the rest in areas of Croatia and Kosovo that require more exploration. Yugoslavia accounts for more than 29 percent of all European bauxite reserves, excluding the European part of the Soviet Union.

Lower bauxite exports are planned, with the whole capacity refined to alumina before export in the future. During 1985 alumina exports should amount to 50 to 60 percent of total production, that is about 800,000 tons or twice as much as at present. Reduction of alumina exports is expected after the year 1990, as all debts to the Soviet Union will have been repayed by that time. In 1985 the export of 120,000 tons of primary aluminum is planned, a level that is two and a half times more than in 1981. Present exports of semi and final products is 50,000 to 55,000 tons a year, about 40 percent of total production.

Recent research has shown that Yugoslavia possesses about 4 percent of world lead ore reserves, or about 22 percent of European reserves. Zinc ore reserves account for about 2 percent of world reserves, about 9.6 percent of European reserves. The largest reserves of zinc are in Kosovo and Macedonia, and lower grades in Bosnia and Hercegovina. The greatest antimony reserves are in Serbia, and in the near future exploration will begin in Bosnia and Hercegovina and Macedonia.

During 1982 mining of iron ore at Suha Ruda in Raska ceased. In the same area of Serbia the Kopaonik lead-zinc deposits have been discovered. The lead-zinc mine and concentrator, Sastavci-Kizevak, will be opened during the next two years. The mine will take all the employees from the iron ore mine, and also the equipment. Development of the new mine will cost about $17,000,000.

The Ljubija iron ore mines produced a record of about 2,500,000 tons. The existing Centralni and Vzhodni mines will be joined by a third, Omarska, in 1984. Total annual production from the Ljubija mines will then reach 4,300,000 tons. The deposits cover an area of about 900 hectares.

The capacity of Omarska mine will grow to about 2,000,000 tons of ore per year. An investment of $50,000,000 is expected for the development. The iron ore reserves of the Ljubija mines amount to over 500,000,000 tons, about 70 percent of all Yugosiav reserves. According to the 1982-85 plan, iron ore production should increase at an annual rate of about 14 percent.

During 1983 development of a barite mine at Bobija near Ljubovije is planned. Reserves, not fully evaluated, amount to over 10,000,000 tons. Annual production will be 150,000 tons of ore, from which about 55,000 tons of concentrate should be produced.

Yugoslavian production of ores in metric tons

Commodity	1980	1981	1982
Iron ore	4,530,000	4,794,000	5,106,000
Copper ore	19,559,000	18,337,000	19,733,000
Lead-zinc ore	4,284,000	4,365,000	4,252,000
Bauxite	3,138,000	3,249,000	3,668,000
Pyrite concentrate	522,000	618,000	541,000
Manganese ore	36,400	33,400	37,100
Chrome ore	3,070	N.A.	2,410
Antimony ore	70,000	66,000	—

1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric tons. N.A. Not Available.

Yugoslavian production of metals and minerals in metric tons

Commodity	1980	1981	1982
Refined lead	101,751	86,401	81,248
Zinc	84,537	96,370	86,767
Electrolytic copper	131,288	132,603	126,878
Primary copper	—	—	88,400
Antimony regulus	2,237	2,198	1,872
Mercury	2	6	—
Aluminum	184,760	196,767	246,363
Bismuth[1]	82,800	102,400	49
Selenium[1]	50,400	61,000	55,000
Silver[1]	149,000	138,100	104,770
Gold[1]	N.A.	17,420	19,344
Pig iron	2,500,000	2,817,200	N.A.
White pig iron	2,181,000	2,571,000	2,455,000
Grey pig iron	244,000	246,200	248,000
Steel	3,537,000	3,834,000	3,976,500
SM-steel	1,459,000	1,504,000	1,464,700
EL-steel	1,026,000	1,048,000	1,037,000
Konv. steel	1,149,000	1,424,500	1,349,200
Ferro-alloys	250,000	243,000	264,300
Coal (total)	47,002,000	52,245,000	54,587,000
Hard coal	388,000	384,000	389,000
Brown coal	9,665,000	10,581,000	10,744,000
Lignite	36,949,000	41,279,000	43,454,000
Coke	2,628,000	2,693,000	2,779,200
Asbestos	12,106	13,501	11,657
Cement	9,315,600	9,779,000	8,480,000
Magnesite	262,000	300,000	328,000
Salt	377,000	418,500	429,000
Fireclay	202,000	182,000	—
Other firesistant material	643,000	673,000	657,000

1. Kilograms. 1.0 metric ton = 1.1 short tons. 1.0 short ton = 0.907 metric ton. N.A. Not available.

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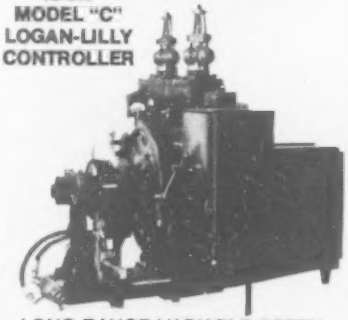

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ARGENTINA

Activity in 1982 was centered in the uranium industry. Uranium production shot up to 465,788 metric tons of ore containing about 784,980 pounds of U_3O_8 from 229,000 tons of ore containing 487,305 pounds of U_3O_8 in 1981.

The most important discovery has been the Schlagintweit deposits in Córdoba. Current production at Schlagintweit is about 231,525 pounds of U_3O_8. An expansion is planned to raise production to 500,000 tons of ore grading 0.29 percent U_3O_8 in an open pit. Approximately 50,000 meters (164,000 feet) of holes were drilled in 1982 and reserves were increased by 1,000,000 tons of low grade ore. Comisión Nacional de Energía Atómica, the national nuclear energy commission, owns the project, and will be pursuing further exploration and development in 1983.

The Malargüe and San Rafael plants produced 396,900 pounds of U_3O_8 and delivered 264,600 pounds to the Brazilian company, Nuclebrás. The Los Gigantes plant, to produce 176,400 pounds of U_3O_8 per year, was inaugurated.

The dispute over the Falklands/Malvinas caused suspension of bidding on Argentina's large Nevados de Famatima and Bajo La Alumbrera porphyry copper deposits and the Nevados de Famatina gold-silver-manganese deposit. Bidding was to be reopened in 1983.

The Compañía Minera Aguilar S. A. mined 668,000 tons of ore and produced 32,286 tons of lead, 34,959 tons of zinc, and 1,688,216 ounces of silver. Production in 1981 was 33,362 tons of lead, 37,258 tons of zinc, and 1,650,000 ounces of silver. Aguilar is owned by St. Joe Minerals Corporation, a subsidiary of Fluor Corporation.

Argentina has about 1,000 mines, 850 of which are open pits. About 40 percent of the mines are mechanized; 35 percent are partially mechanized.

Argentine production of metals in metric tons

Commodity	1980	1981	1982
Iron ore	710,000	397,640	314,000
Lead	34,800	32,652	27,875[r]
Zinc	36,900	35,150	36,376[r]
Manganese	9,700	2,706	1,800
U_3O_8[1]	220,400	487,305	784,980[r]
Tin	500	423	303[r]
Silver[2]	2,305,000	2,100,000	2,518,310
Gold[2]	11,000	14,757	15,271
Wolframite[r]	N.A.	48,290	74,970
Contained copper	N.A.	80	114[r]

1. Estimated. 2. Pounds. 3. Ounces. N.A. Not Available. 1.0 metric ton = 1.10 short tons. 1.0 short ton = 0.907 metric ton.

BOLIVIA

By **Oscar M. Dávila**
Consultaria Metalúrgica Minera

Bolivia faced continuous social and political problems in 1982. A democratic government, headed by Hernán Siles Zuazo as president, was elected in November after almost two decades of military rule. Whether this change will mean any increases in productivity and production is a question that will be answered in the future.

Mineral production in 1982 was even lower than in 1982. Low mineral output is highly significant in Bolivia because the country's dollar income comes from exports of minerals, metals, and natural gas. Bolivia was also affected by the lower metal prices prevailing in the international market and the continuous escalation of machinery and materials prices.

The tin volatilization plant in La Palca, Potosí had its first full year of operations in 1982 and, according to limited information available, results were satisfactory. The plant's main difficulty was in obtaining a continuous supply of low-grade tin products that have a higher than 3 percent Sn content. In light of this problem, it is difficult to justify a tin volatilization plant under construction in Machacamarca, Oruro.

At the end of 1982, the Karachipampa lead and silver smelter was in the final stages of construction. This smelter has a 25,000-ton per year capacity and will cost $154,000,000. The smelter will face the same problem of a lack of feed because lead mining in Bolivia is very limited. At present lead prices, Bolivian lead mining is also not economical.

According to the limited information available, Bolivia has an important gold potential. The Tipuani, Guanay, and Mapiri areas have produced gold for many decades. Because of the acute economic crisis facing Bolivia, many small miners are trying to survive by producing gold. Hundreds of prospectors are looking for gold in eastern Bolivia.

Banco Minero reported a production of 40,145 ounces of gold in 1982. The Ministry of Mining and Metallurgy has put actual production at over 321,500 ounces. The difference is gold smuggled out of Bolivia to neighboring countries.

Corporación Minera de Bolivia (Comibol), the state-owned mining company, remains in deep economic trouble. The government has looked for financing from the World Bank and other sources; it is also studying "cogestion obrera," a system of labor participation at all levels of management.

Bolivian metal and mineral exports in metric tons

Commodity	1980	1981	1982
Tin	22,530	29,780	26,772
Lead	15,936	16,757	12,433
Zinc	46,236	47,029	45,667
Antimony	12,622	15,301	13,977
Copper	1,675	2,637	2,270
Wolframite	3,435	3,449	3,195
Bismuth	547	11	5
Silver[1]	5,678,218	6,601,568	6,003,634
Gold[2]	N.A.	N.A.	40,145
Cadmium	N.A.	N.A.	134

Source: Ministerio de Minas y Metalurgia. 1. Troy ounces. N.A. Not available. 1.0 metric ton = 1.10 short tons. 1.0 short ton = 0.907 metric ton.

Corporación Minera de Bolivia's production of metals and minerals in metric tons

Commodity	1980	1981	1982
Tin	18,620	20,828	17,910
Silver[1]	5,123,140	5,492,915	4,612,428
Lead	10,152	9,598	7,226
Bismuth	10	9	5
Copper	1,797	2,622	2,266
Wolframite	1,576	1,424	1,252
Zinc	29,953	27,216	23,726
Cadmium	134	122	93
Gold[2]	N.A.	N.A.	N.A.

Source: Ministerio de Minas y Metalurgia. 1. Troy ounces. N.A. Not available. 1.0 metric ton = 1.10 short tons. 1.0 short ton = 0.907 metric ton.

Bolivian production of metals and minerals in 1982 in metric tons by size of mines

Metal	Comibol	Medium mines	Small mines	Total
Tin	17,910	6,026	2,836	26,772
Copper	2,266	—	4	2,270
Lead	7,226	4,018	1,189	12,433
Zinc	23,726	19,063	2,878	45,667
Wolframite	1,252	1,576	367	3,195
Silver[1]	4,203,934	760,348	507,648	5,471,930
Bismuth	5	—	—	5
Antimony	366	10,182	3,429	13,977
Cadmium	93	41	—	134
Gold[2]	N.A.	4,899	35,246	40,145

Source: Ministerio de Minas y Metalurgia. 1. Troy ounces. N.A. Not available. 1.0 metric ton = 1.10 short tons. 1.0 short ton = 0.907 metric ton.

BRAZIL

Despite the serious slowdown in the general economy, on the whole, Brazil's mineral industry did very well in 1982. According to figures from the Departmento Nacional de Produção Mineral (DNPM), the value of mineral production grew 9 percent, or $7,288,000,000, from 1981 to 1982. The two highest value increases were in gold, up 87 percent, and lead, up 67 percent.

Brazil produced 4,500,000 metric tons of bauxite last year, up about 1,000,000 from 1981. Mineração Rio do Norte (MRN), a joint venture between Companhia Vale do Rio Doce (CVRD), the Votorantim group, Alcan Aluminum Ltd., and several other foreign companies, was the largest producer. (MRN has delayed plans to expand bauxite production from 3,150,000 to 6,700,000 tons in 1983.) MRN was closely followed by Alcoa Aluminio S. A. and Companhia Brasileira de Aluminio (CBA).

CBA led aluminum production with an output of 96,600 tons. Alcoa produced 89,600 tons, and Alcan Aluminio do Brasil S. A., 88,500 tons. CVRD's Valesul smelter went on stream in April 1982 and produced 24,200 tons. Valesul is expected to reach full capacity by the end of 1983.

Aluminio do Maranhão S. A.'s (Alumar) refinery/smelter complex, a joint venture between Alcoa and Billiton B. V., is well underway. Located in São Luiz de Maranhão, the plant is designed to produce 500,000 tons of alumina and 100,000 tons of aluminum per year by 1984.

The Aluminio Brasileiro S. A. (Albrás) smelter, a joint venture betwen CVRD and Nippon Amazon Aluminum Company, is being built in Barcarena, Pará. Initial production will be 80,000 tons of aluminum per year, eventually rising to 320,000 tons per year. Start-up is scheduled for 1985. The Alumina do Norte Brasil S. A. (Alunorte) project, owned by the same parent companies, has been delayed because of poor markets. Start-up date would be 1988 at the earliest.

Aluminio do Brasil Nordeste, an Alcan subsidiary, is progressing on a $200,000,000 expansion project for the Aratu smelter in Bahia. After the expansion, the plant will have a 118,000-ton per year capacity.

Alcoa, associated with Billiton, has started a feasibility study on constructing an aluminum smelter in the Amazonas region. The plant would be supplied by Daniel Ludwig's former mine, now owned by Alcoa. Initial costs are estimated at $600,000,000. There is no start-up date at present.

The most important event in Brazil's copper sector in 1982 was the start-up of the Caraíba Metais smelter. A subsidiary of Banco Nacional do Desenvolvimento Econômico (BNDE), the national economic development bank, Caraíba Metais is located 500 kilometers (300 miles) northeast of Bahia in the district of Camaçari. The smelter has a production capacity of 160,000 tons per year of electrolytic copper. In 1982, 9,573 tons were produced.

Companhia Brasileira de Cobre, also a subsidiary of BNDE, started producing copper last year in the Camaquã mines in Rio Grande do Sul. The operation will eventually produce 12,000 tons per year of copper concentrate.

The Eluma group, associated with Noranda Mines Ltd., has begun development of a copper mine in the Mara Rosa district in Goiás. Planned production capacity is 40,000 tons of copper concentrate per year.

It is not yet decided which company will develop the Carajás copper deposits (see WORLD MINING, January 1983, page 50 to 57). CVRD, through its exploration subsidiary Rio Doce Geologia e Mineração (Docegeo), has submitted a project application to the Interministerial Council on the Grande Carajás Project. At present, the Council appears to favor a private capital project. The Eluma-Noranda group, Outokumpo Oy, and the Soviets seem to be the strongest candidates.

Although a modest tin producer—the world's sixth largest—Brazil's tin industry has drawn the interest of investors, foreigners as well as Brazilians. The main project, owned by the private Paranapanema group. began last year with a $20,000,000 exploration program to prove a reserve with the potential to produce 30,000 tons per year of high-grade tin concentrate.

A subsidiary of Metais de Goiás and the Brumadinho group, Goiás Estanho is studying a project to develop Brazil's first underground cassiterite mine. Estimated production capacity of a plant at the site would be 2,000 tons per year of contained tin.

Brazil's iron ore production grew 32 percent in 1982, although net exports suffered an 8,000,000-ton decline, to 71,500,000 tons. As a consequence of the decrease in sales, most producers have postponed expansion plans. Minerções Brasileiras Reunidas S. A. (MBR) plans to expand annual output to 29,500,000 tons by the end of 1986, at a cost of $615,000,000, were set aside.

On the other hand, the Minas Serra Geral mine (a CVRD and Kawasaki Steel joint venture) was officially opened in Ouro Preto, Minas Gerais, with an initial production of 7,000,000 tons per year, to be increased to 11,500,000 tons.

Despite the bleak market outlook, the Carajás iron ore project is moving ahead. The plant is expected to produce 35,000,000 tons per year of sinter feed. Annual capacity will eventually be raised to 50,000,000 tons. However, start-up may be delayed if poor world markets persist. A year's delay, to 1986, is already definite. CVRD is trying to cut costs from the initial estimate of $4,500,000,000, to $3,500,000,000.

Brazil's largest columbium producer, Companhia Brasileira de Mineração e Metalurgia (CBMM), a subsidiary of Moreira Salles and Union Oil, reduced output by 50 percent in 1982. Nevertheless, Brazil's columbium output grew 19 percent compared to 1981 because of production from Mineração Catalão in Goiás. Goiás Nióbio, a Metago-Prometal venture, is working on a $10,000,000 project to produce 3,260 tons of niobium oxide and tantalite per year.

In 1982, for the first time, Brazil had a domestic supply of nickel. Brazil eventually expects to be self-sufficent from two new projects that went on steam last year: Nickel Tocantins and Codemin.

Companhia Nickel Tocantins, a sub-

Brazilian ore and mineral production in metric tons

Company	1980	1981	1982
Bauxite	4,151,660	3,569,400	4,500,000
Beryl	450	811	N.A.
Copper	10,000	45,000	66,573
Gold[1]	482,330	514,488	1,446,750
Zinc	70,000	67,120	110,434
Columbite-Tantalite	290	320	200
Tungsten, 70 percent WO_3	1,950	1,574	1,400
Chromite	925,000	308,000	120,000
Nickel	2,540	2,340	4,808
Aluminum	505,940	293,306	346,203
Tin, Cassiterite	10,639	7,789	9,298
Manganese Ore	1,249,691	1,250,000	1,300,000
Iron ore	111,800,000	108,281,000	110,000,000
Diamonds[2]	84,000	1,089,000	529,760

1. Troy ounces. 2. Carats. N.A. Not available. 1.0 metric ton = 1.10 short tons. 1.0 short ton = 0.907 metric ton.

Brazilian production of iron ore, concentrates, and pellets by companies in long tons

Country	1980	1981	1982
Companhia Vale do Rio Doce	71,312,000	86,913,200	72,994,000[1]
Empresa de Mineração Esperança S.A.	135,630	98,000	52,000
Ferteco Mineração S.A.	2,900,000	8,881,000	8,613,000
Cia. Hispano-Brasileira Pelotização[2]	1,858,000	1,872,300	2,148,000
Nibrasco[2]	5,305,000	4,279,100	4,391,000
Italo-Brasileira de Pelotização S.A.[2]	2,467,000	2,093,800	2,450,000
Minerções Brasileiras Reunidas S.A.	14,484,100	12,745,342	10,832,000
W. H. Muller S.A.	1,122,900	432,067	637,011
S. A. Mineração da Trindade	6,665,500	6,410,497	7,089,699
Samarco Mineração S.A.			
Pellets	3,374,300	3,047,450	2,605,903
Concentrate	790,460	1,050,337	1,228,897

1. Production from company mines was 53,896,000 tons.
2. Pellets.

sidiary of the Votorantim group, has a mine located in Goiás and an electrolytic plant in São Paulo, in the district of São Miguel Paulista. The plant had to be built in São Paulo because of the lack of a supply of power at the mine. The plant's production capacity is 10,000 tons per year of electrolytic nickel. The Empresa de Desenvolvimento de Recursos Minerais (Codemin) project, also located in Goiás, will produce 6,000 tons of ferronickel per year.

Brazil significantly increased its gold production in 1982 due to the mining of alluvial deposits along the Tapajós and Madeira Rivers. The Jaobina mine, owned by Mineração Morro Velho S. A., came on steam in Bahia. Initial annual production capacity is 48,200 ounces, which is expected to rise to 96,500 ounces per year.

Volta Grande, a $1,300,000 state government project, is expected to produce 100,000 ounces of gold per year. Production began in 1982. Owned by Companhia Sul Rio Grandense de Mineração, the project is located in Lavras do Sul district in Rio Grande do Sul.

Morro Velho will spend an estimated $200,000 on an expansion of the Nova Lima mines, which have been producing for 150 years. The project includes the development of two underground gold mines and a metallurgical plant with a capacity to produce 257,200 ounces of gold per year starting in 1983. A sulphuric acid plant will also be built.

Brazil has large proven deposits of anatasium that are not included in the titanium production rank. Three projects are underway to change this situation. CVRD has developed a process to turn anatasium into titanium oxide, and plans a $27,000,000 project to produce 150,000 tons per year. The plant is located in Itapira, Minas Gerais.

The second, an Inercal project (part of the local Odebrecht group), will spend about $2,900,000 to explore an anatasium deposit in the district of Floresa, Pernambuco. Estimated production capacity would be 100,000 tons per year.

The third project, located in Mataraca, Paraíbais, is owned by Rutilo-Imenita do Brasil (Bayer group). A production of 102,000 tons per year of titanium, plus 25,000 tons per year of zirconite, is planned. The project will require an investment of $32,000,000.

In 1982 the bulk of general geological research was done in the Amazonas region, and potential ore bodies with large non-ferrous reserves were found near the Jari River. The Radambrasil project, based on aerophotogram studies, has developed an exploration plan through the northeast region. Besides important discoveries of underground water reserves, some chromite, gold platinum, paladium, emerald, lead, copper, zinc, iron, graphite, scheelite, and phosphate mineralizations were found.

CHILE

Chile became the world's largest copper producer in 1982 with a production of 1,240,700 metric tons. Corporación Nacional de Cobre del Chile (Codelco) produced 1,032,900 tons; Empresa Nacional de Minería (Enami), 81,300,000 tons; Empresa Minera de Mantos Blancos S. A., 57,400,000 tons; and Compañía Disputada de las Condes S. A., 43,200,000 tons. Codelco made an aftertax profit of $160,600,000, up 61.6 percent compared to 1981.

Codelco expects to boost production at its Andina mine with the development of the newly-discovered Sur-Sur deposit. Reserves at Sur-Sur are estimated at 50,000,000 tons of ore grading an average of 1.5 percent copper. Under a 4 percent copper ore cap lies an estimated 10,000,000 tons of 2.5 percent ore. Production from Sur-Sur should begin in 1983. Concentrator capacity at the mine will be raised from 14,000 to 20,000 tons per day by 1984.

At the Chuquicamata mine, Codelco is driving a haulage adit to link a lower level of the mine with the concentrator. The project, expected to be completed in 1987, is part of Codelco's plan to maintain the mine's production at 500,000 tons of metal per year.

Disputada de las Condes expected to make a decision on expanding the Los Bronces copper mine by the end of 1982

Copper production in Chile in short tons by four big mines and the small and medium sized mines

Year	Chuquicamata	El Salvador	Andina	El Teniente	Total Big Four	Small and Medium	Grand Total
1970	289,297	102,316	6,574	194,418	594,725	166,210	760,935
1971	275,206	93,400	58,942	162,008	628,346	150,700	779,046
1972	257,694	91,182	59,356	209,323	651,875	136,620	788,495
1973	292,632	92,420	61,763	196,006	677,447	121,000	798,447
1974	392,481	87,998	75,218	248,081	839,183	157,208	996,391
1975	335,060	89,430	68,640	257,400	750,530	149,600	900,130
1976	490,050	90,970	62,590	287,870	931,480	174,240	1,105,720
1977	525,629	88,947	64,363	303,191	982,130	145,000	1,127,130
1978	550,700	85,250	52,470	275,660	964,080	210,320	1,174,400
1979	557,900	85,910	51,370	306,020	1,001,200	165,900	1,167,100
1980	562,100	82,600	57,700	292,500	994,900	184,500	1,179,400
1981	520,825	84,388	58,145	321,848	985,206	205,837	1,191,043
1982	609,462	99,005	370,330	59,976	1,138,772	229,100	1,367,872

Chiquicamata, El Salvador, Andina, and El Teniente are divisions of Corporación del Cobre, largest copper mining company in the world.

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but is continuing to review the project. Exxon Minerals Chile Inc., which owns Disputada, appears to be looking at a scaled down version of its original plant to increase production from 20,000 to 80,000 tons of ore per day.

Anaconda Company has not yet made a decision on whether to go ahead with development of the Los Pelambres deposit. Reserves are calculated at 500,000,000 tons of ore grading 0.78 percent copper.

Several other large copper projects are also on hold. Bidding was suspended in December 1982 on the Andacollo copper project because of poor international markets. The deposit contains estimated reserves of 250,000,000 tons of ore grading 0.55 percent copper. Enami decided to wait before putting the El Abra deposit up for sale. El Abra has estimated reserves of 190,000,000 tons of copper oxide ore grading 0.66 percent copper and 1,178,000,000 tons of copper sulphide ore grading 0.58 percent copper. Development of the Quebrada Blanca deposit, which contains 440,000,000 tons of material grading 0.81 percent copper and 0.018 percent molybdenum, is not considered economically feasible.

The most exciting news in Chile in 1982 was that the La Escondida porphyry copper deposit contains an estimated 382,000,000 tons of ore grading an average of 1.92 percent copper. Molybdenum and silver are also contained in minor quantities. A decision on the project, owned by Getty Mining (Chile) Inc. and Minera Utah de Chile Inc., is expected to be made in 1984. Part will be suitable for open pit mining.

Chilean metal and mineral production in metric tons

Commodity	1980	1981	1982
Copper	1,057,900	1,081,100	1,240,700
Molybdenum	13,668	15,360	20,047
Iron ore	8,834,600	8,514,200	8,471,300
Gold[2]	219,777	375,898	539,638
Silver[2]	9,598,222	10,617,055	12,180,091
Manganese	27,701	25,557	16,123
Nitrate	629,400	631,200	576,750
Iodine	2,601	2,698	2,609
Rhenium	8,400	10,000[2]	N.A.
Coal	1,024,287	1,168,963	996,804
Lead	461	242	1,478
Zinc	1,134	1,523	5,486

1. Troy ounces. 2. Estimated to be at least 10,000 tons. N.A. Not available. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

Chilean production of molybdenum by mines in metric tons

Company	1979	1980	1981	1982
Chuquicamata	9,258	9,330	9,884	14,257
El Salvador	1,212	1,335	1,314	1,739
Andina	508	691	682	420
El Teniente	2,581	2,312	3,480	3,632
Totals	13,559	13,668	15,360	20,048

Compañía de Acero del Pacífico S. A. production of iron ore in long tons

Company	1980	1981	1982
Algarrobo	3,178,731	3,067,000	4,036,000[1]
Romeral	4,040,100	3,463,000	1,957,000
Santa Fe	1,055,000	999,000	144,000
Totals	8,273,831	7,529,831	6,137,000

1. Pellets—3,286,000 tons.

Compañía Minera El Indio S. A., in its first calendar year of operation, recovered 368,000 ounces of gold and 2,600,000 ounces of silver from the El Indio mine. Milling grade ore reserves have been increased to 4,700,000 tons assaying 0.30 ounce gold, 3.6 ounces silver, and 5.1 percent copper per ton. High-grade direct shipping ore totalled 68,656 tons assaying 7.3 ounces of gold and 3.3 ounces of silver per ton. Four gold-silver veins have been found at the El Tambo deposit, four miles (6 kilometers) southeast of El Indio, and may supplement El Indio ore for the mill. El Indio is 80 percent owned by St. Joe Minerals Corporation.

Exploration and feasibility studies, financed by St. Joe Minerals, Anglo American Corporation, and Mantos Blancos, are being conducted at the El Nevado gold-silver-copper project. El Nevado is located in the Andes, about 150 kilometers north of El Indio. Two more years of study are needed before the deposit can be delineated.

Compañía de Acero del Pacífico S. A. (Cap) was unsuccessful in finding a buyer for its iron ore holdings. Cap had hoped to sell its Algarrobo, El Romeral, and Sante Fe mines, and the Huasco pellet plant by the end of 1982.

COLOMBIA

Cerro Matoso, the $400,000,000 laterite nickel plant, went on stream in June 1982. Shipment of 205 metric tons of ferronickel was received in Baltimore, Maryland, United States on October 30.

Annual production at the plant will be 42,000,000 pounds of ferronickel grading 37.5 percent nickel. Reserves are estimated at 40,000,000 tons of ore with an average 2.71 percent nickel.

Ecominas, the state mining company, has several projects underway. Exploration in the lower zone of the Marmato gold project in Caldas has delineated 350,000 tons of ore containing between 0.225 and 0.322 ounce gold per ton. An operation to produce about 5,150 ounces of gold per year is being considered.

Reserves at the Pantanos-Pegadorcito porphyry copper deposit have been estimated at 400,000,000 tons of ore grading 0.4 percent copper. Reserves at Patascoy porphyry copper deposit in Macoa are 200,000,000 tons, 0.8 percent copper and 0.06 percent molybdenum.

A feasibility study on a bauxite project in the Valle and Cauca departments is being conducted. Ecominas also plans to examine the feasibility of building a 240,000-ton per year smelter.

Colombia produced 469,432 ounces of gold in 1982, down from 524,550 ounces in 1981. Silver production was 125,848 ounces, compared to 136,054 ounces of silver in 1981. Platinum output in 1982 was 20,000 ounces.

COSTA RICA

The Santa Clara mine of Minera Macacona S. A. produced about 350 metric tons of ore per day in 1982, and expected to increase production in 1983 with a new mine operator and the installation of a continuous rotary drum agglomerator. Production in 1982 was about 2,500 ounces, or between 175 and 220 ounces per month, by heap leaching. The Santa Clara mine is owned by United Hearne Resources (60 percent) and Canadian Barranca Corporation (40 percent).

Plans call for an eventual expansion to 2,800 tons of ore per day. Proven reserves at Santa Clara are 4,700,000 tons of ore grading 0.059 ounce gold per ton. The ore is nearly pure clay.

The Costa Rican government, like most Latin American governments, is looking at increasing gold production to strengthen the domestic economy. The government has proposed the creation of a state gold refinery that would serve both to raise domestic gold production and reduce gold smuggling.

ECUADOR

Minera Toachi S. A.'s La Plata mine, Ecuador's largest mining operation, was shutdown throughout 1982. Production at the mine in 1981 was 2,500 metric tons of copper concentrate, 1,720 tons of zinc concentrate, and 24 tons of gold-bearing pyrite concentrate. Minera Toachi is 39 percent owned by the Finnish company, Outokumpu Oy.

The government, through Comisión Ecuatoriana de Energía Atómica, approved a $1,600,000 uranium exploration project. It will be sponsored jointly by the United Nations and the International Atomic Energy Commission.

GUATEMALA

The nickel mining and processing facilities of Inco Ltd.'s 80-percent owned Guatemalan subsidiary, Exploraciones y Explotaciones Mineras Izabal S. A., were mothballed in early 1982. Cash requirements for the plant were estimated at about $3,000,000. Inco does not project a reopening in the near future.

GUYANA

Production of alumina and bauxite continued to decline in 1982. Guyana Mining Enterprise Ltd. (Guymine) produced 1,177,972 metric tons of calcined, metallurgical, and chemical grade bauxite in 1982, down from about 1,489,000 tons in 1981. Alumina production was

73,135 tons, down from 170,000 tons in 1981 and 215,000 tons in 1980. Bauxite production by grade was (1981 in parentheses): calcined, 391,066 (514,000) tons; metallurgical, 448,271 (640,000) tons; and chemical, 319,595 (335,000) tons. Guymine also produced 15,444 tons of aluminous cement grade bauxite and 3,596 tons of abrasive "A" grade calcined bauxite.

Norman Mines Ltd. sought public financing to continue a gold exploration drilling program at its Marudi Mountain property. The Canadian company plans to drive an adit into Mazoa Hill and then begin underground exploration drilling. In the 1940s, Canadian Rupununi Gold Mining Company estimated reserves at Marudi Mountain at 230,000 tons of ore asaying 0.34 ounce gold per ton. Norman Mine's first drill hole intersected three mineralized zones: 100 feet grading 0.23 ounce gold per ton, 29 feet grading 0.18 ounce per ton, and 41 feet assaying 0.21 ounce per ton.

Cogema of France has signed an agreement with the government to explore for uranium in the Essequibo region. Cogema has surveyed the area for two years. If sufficient uranium is found, a joint venture company will be set up.

HONDURAS

Some exploration and mining projects were held up last year pending long-awaited, additional mining taxation reduction. Properties that fell into this category included the Quita Gana copper deposit explored and developed by EMHOSA, a subsidiary of Noranda Mines Ltd. of Canada; Pamexco's Mina Arena Blanca silver and gold prospect; and the Moramulca and St. Marcus gold and siver mines owned by Compañía Minera San Marcos, a subsidiary of Canadian Javelin Ltd. The new government made some reductions in taxes, mainly benefiting larger producers.

Production at Amax Inc.'s El Mochito mine, currently being expanded, jumped from 343,000 tons of ore in 1981 to 475,716 tons of ore in 1982. Metal production was (1981 in parentheses): 2,052,393 (1,667,000) ounces of silver, 16,667 (13,939) tons of contained lead, and 27,066 (17,844) tons of zinc. The mine was producing 1,800 tons of ore per day at the end of the year, and an average of 1,570 tons per day through the year. Expansion to 2,500 tons per day is expected to be completed in 1984 to 1985.

Mining of La Pochota silver property will begin in 1983. Natural Resources Development Ltd. (Derena) has begun cleaning up old gold mines. A KHD mobile mill will be used to facilitate early production, eliminating long waiting time and dependency on fixed ore reserves required by stationary mills.

Two companies are carrying out small-scale gold placer exploration and mining operations along the Guayape River. Barite exploration began near Suyapita, Olancho.

Government departments and agencies expressed an interest in a free Side-Looking Airborne Radar (SKLAR) demonstration survey offered by Intera-Intertech, a Canadian company. The survey would cover two areas of 10,000-square (4,000-square miles) kilometers each, and be interpreted by Hunting Geology & Geophysics Ltd. of the United Kingdom, with Svanholm, Flores & Associates of Honduras providing the groundtruthing expertise. But the government refused to issue a flight permit and the survey had to be cancelled.

A lead smelter prefeasibility study was being carried out with the help of the Inter-American Development Bank during the latter part of 1982. Several lead-silver deposits, of which the Mochito deposit is the largest, would benefit from the construction of a smelter.

The outlook for the future is promising, as the new government shows definite interest in reviving the mining industry. Further taxation reductions are expected. The investment potential is large: over 500 showings, prospects and old mines are known. The residual, eluvial, and alluvial gold potential has not yet been studied systematically. Little explored and unexplored areas offer additional opportunities. If the SKLAR survey materializes, additional important geologic information relating to extensions of mineralized structure and new structure will be available.

MEXICO

The peso devaluation in December ended a dismal year on a slightly upbeat note. For the most part, the 1982 peso devaluations helped the mining industry, which receives dollars for production and pays operating costs in pesos. But the net effect of Mexico's financial crisis was to slow down expansions and new projects. External financing was difficult to obtain and importation of equipment and parts was virtually impossible.

The nationalization of the banks in September added an additional element of insecurity. The banks owned many mining companies, and it is not yet known who will take over these holdings, although it is believed the interests will remain in private hands.

Mexican production of metals in metric tons

Metals	1980	1981	1982
Gold[2]	195,986	203,155	196,244
Silver[1]	47,342,707	51,654,829	49,839,605
Copper	175,399	230,466	239,091
Molybdenum	59	451	5,190
Lead	145,549	157,384	145,844
Zinc	238,231	211,629	231,910
Iron ore	5,087,361	5,292,609	5,382,239
Manganese	160,966	208,193	183,120
Antimony	2,176	1,800	1,565
Barite	269,322	317,138	323,753
Fluorspar	916,455	924,854	631,386
Coal	6,408,464	6,965,000	6,236,000[2]
Sulphur	2,102,301	2,077,117	1,815,447

1. Troy ounces. 2. Estimated. N.A. Not available. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

During the most depressed part of 1982, Minera Frisco S. A. de C. V. was considering shutting down Cumobabi, Mexico's only molybdenum mine. Output in 1982 was even lower than in 1981. Despite low production at Cumobabi, Mexico's molybdenum output jumped from 451 to 5,190 metric tons because Mexicana de Cobre S. A.'s La Caridad mine began operation of its molybdenum circuit. La Caridad's new 180,000-ton per year flash smelter was scheduled to go on stream in late 1983.

The Cananea copper mine expansion was slowed down, although the 50,000-ton per day concentrator was still scheduled to begin operations in 1985. Total production will be raised to 82,000 tons of ore per day. The country's shaky financial situation caused the International Finance Corporation to postpone a $400,000,000 loan to Compañía Minera de Cananea, and the Mexican company was proceeding with available resources.

The major event of 1982 was the start-up of the Real de Angeles silver mine. Problems in the tailings thickener were resolved and the mine was operating at close to full capacity of 10,000 tons of ore per day by the end of the year. Annual production at Real de Angeles will be 7,000,000 ounces of silver, 31,000 tons of lead, and 27,000 tons of zinc.

Despite the start up of Real de Angeles, silver production in Mexico fell from 51,654,829 to 49,839,605 ounces in 1982. Mexico dropped into second place, after Peru, on the list of the world's leading silver producers.

The expansions at Industrial Minera México S. A.'s (Immsa) Santa Barbara lead-copper zinc mine and its Taxco silver-zinc mine were to be completed in 1983. The San Martín silver-lead-zinc mine is being expanded from 2,400 to 6,800 tons of ore per day. Immsa's 114,000-ton per year San Luís Potosí zinc refinery went on stream in October. The mines feed Immsa's Nueva Rosita smelter, which supplies the new refinery.

NICARAGUA

Companhia de Pesquisa de Recursos Minerais (CPRM), a Brazilian company, planned to begin prefeasibility studies in January 1983 on the inactive El Topazio gold mine. The government selected CPRM in September 1982 to provide basic engineering services for El Topazio. The World Bank has lent Nicaragua $400,000 to resume production at the mine, which will be operated by the Nicaraguan Institute of Mining.

The government agreed to pay Neptune Mining Company $3,700,000 plus interest for gold and silver confiscated in

1979 when Neptune mines were nationalized. Payment is for 9,300 ounces of gold doré and 11,800 ounces of silver doré. Neptune is owned by Asarco Inc. (52.3 percent), Amax Inc.'s Rosario Resources Corporation (36.2 percent), and individual stockholders (11.6 percent).

PANAMA

Joint venture partners Corporación de Desarrollo Minero (Codemín) and Rio Tinto-Zinc Corporation decided to indefinitely delay the Cerro Colorado copper project. The earliest development could begin is 1985, with first production beginning in 1990.

Impediments are low copper prices, high energy costs, and certain environmental concerns. Estimated reserves are 1,300,000,000 metric tons of ore grading 0.78 percent copper, 0.16 ounce silver, and 0.001 ounce gold per ton.

Early in 1982, Panama Resource Development Company and the Panamanian government asked Japan to fund half of a $3,000,000 exploration project to explore and delineate the Petaquilla porphyry copper deposit. Panama Resource Development is a joint venture of Mitsui Mining and Smelting Company, Dowa Mining Company, and Mitsubishi Metal Corporation. The deposit was explored from 1973 to 1976. Reserves were estimated at 200,000,000 tons of low grade copper mineralization. However, in light of present copper prices, activity on this project is now doubtful.

PERU

Export earnings from mineral production continued its downward trend in 1982. Copper, zinc, silver, tungsten, antimony and tin production were up in 1982, but mining export revenue fell 14 percent, to $1,300,000,000. Earnings from the mining sector made up 41.4 percent of the country's $3,230,000,000 of export earnings, a decline from 47.9 percent of $3,250,000,000 in 1981.

Because of low silver prices, president Fernando Belaúnde Terry suspended new sales of refined silver for two months, until prices went up to $8.00 per ounce. Peru achieved a record production of 53,200,000 ounces, up from 44,600,000 ounces in 1981, and became the world's largest silver producer. Nevertheless, silver export revenue fell 34 percent, to $206,000,000.

Export copper revenue dropped 13 percent, to $459,000,000. Despite extremely low copper prices, Southern Peru Copper Corporation, one of the lowest cost producers in the world, was able to make a profit of $5,400,000 after credits from deferred tax benefits and participation of labor shares and the joint venturer. Southern Peru suffered less labor unrest in 1982 than in 1981, and copper and molybdenum production was higher. An expansion of the Toquepala mine has been delayed indefinitely.

The biggest project completed in 1982 was the expansion of Empresa Minera Centro del Perú's (Centromín) Cobriza mine, inaugurated in May. The expansion represented the first major increase in Peru's copper production in six years. Annual production was expected to be raised from 65,700 to 224,000 dry tons of concentrate averaging 25.4 percent copper, and daily production was to be 10,000 tons of ore grading 1.76 percent copper. Later in the year Centromín lowered ore grade estimates to 1.39 percent, which will reduce annual concentrate production to 168,400 tons.

Centromín's 1982 production was the highest registered in the company's history, both in total and in the metal contents of lead, silver, and zinc. Nevertheless, Centromín has lost $105,600,000, compared to a profit of about $1,700,000 in 1981. All projects without financing were put on hold. The company's only major project scheduled to go on stream in 1983 was a lead sinter plant at La Oroya. La Oroya lead production will be raised from 80,000 to 95,000 metric tons per year, and silver from 22,600,000 to 24,600,000 ounces per year.

At the end of 1982, work on Empresa Minera del Perú's (Minero Perú) Cerro Verde II project was at a standstill. Because of the weak copper markets, the Japanese consortium financing the project with a $130,000,000 loan decided to hold up disbursements unless the loan was guaranteed by the Peruvian government. (Payment was to be 75 percent of production from the mine over 14 years.) Already burdened with a high foreign debt, the Peruvian government would not go ahead and guarantee the loan. Negotiations have been unsuccessful.

Cerro Verde I, a copper oxide deposit, has been mined since 1977 and is expected to be depleted by 1984. Cerro Verde II is the sulphide portion of the mine. Minero Perú has planned a production of 20,000 tons of ore per day beginning in 1985. Annual production would be 200,000 tons of copper concentrate grading about 30 percent copper, equivalent to 50,000 tons of fine copper.

The Tintaya mine development and the Andaychagua expansion are Peru's most advanced copper projects. Production at the Tintaya copper mine is scheduled to begin at the end of 1984 at an annual rate of 180,000 tons of 30 percent copper concentrate. Production at the Andaychagua mine will be raised from 200 to 1,000 tons of ore per day, for an annual output of 1,200,000 ounces of silver, 6,000 tons of lead concentrate, and 28,000 tons of zinc concentrate. Start-up is planned for 1985.

New copper projects now under consideration include the Tambo Grande project of the Bureau de Recherches Géologiques et Minières (BRGM). A feasibility study on the project, which has estimated reserves of 42,300,000 tons of ore grading over 2 percent copper, 1 percent zinc, and 1 ounce silver per ton, is being conducted. Metallgesellschaft is looking for partners for the La Granja project. Estimated reserves are 231,000,000 tons of ore grading 0.82 percent copper and 0.12 percent silver. Development of the Antamina, Quella-

Peruvian production of metals and minerals in metric tons

Commodity	1980	1981	1982
Iron ore	5,890,000	5,983,000	5,597,000
Lead	175,057	186,700	175,800
Zinc	447,170	496,700	507,100
Copper	363,600	327,600	356,300
Antimony	702	235	296
Silver[1]	38,609,700	44,600,000	53,180,000
Molybdenum	2,300	1,054	2,873
Tungsten[2]	250	657	825
Bismuth	520	454	604
Cadmium	172	182	179
Gold[1]	125,800	157,000	175,000[3]
Tellurium	21	21	21
Selenium	23	22	21
Indium[1]	116,064	112,174	118,101

1. Troy ounces. 2. WO_3 in concentrates. 3. Estimated. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

Empresa Minera del Centro del Perú's production of principal metals in metric tons

Commodity	1980	1981	1982
Copper	54,095	50,018	53,556
Lead	81,980	79,222	76,990
Zinc	63,820	67,955	68,489
Silver[1]	25,796,824	23,853,133	24,619,149
Bismuth[2]	1,097,034	1,408,065	1,331,950
Gold[2]	42,455	42,425	45,216
Cadmium[2]	379,066	402,007	394,142
Tellurium[2]	46,120	46,981	45,693
Selenium[2]	50,504	49,556	45,969
Antimony[2]	940,493	986,798	952,948
Arsenic trioxide[2]	5,456,810	4,770,776	3,665,980
Indium[1]	116,064	112,174	118,101

1. Troy ounces. 2. Pounds. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

Southern Peru Copper Corporation's ore, waste, and mineral production at Toquepala and Cuajone in short tons

Commodity	1980	1981	1982
	TOQUEPALA		
Total ore and waste mined	47,420,000	39,059,000	38,121,000
Ore milled	15,797,000	13,236,000	15,405,000
Percent copper in ore	0.92	0.93	0.97
Blister copper produced	N.A.	102,024	112,699
Molybdenum concentrate produced	3,196	1,934	2,542
	CUAJONE		
Total ore and waste mined	67,202,000	55,900,000	59,755,000
Ore milled	16,576,000	15,854,000	19,395,000
Percent copper in ore	1.15	1.07	1.02
Blister copper produced	N.A.	150,630	152,784
Molybdenum concentrate produced	2,277	3,041	3,249

N.A. Not available. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

veco, Toromocho, and Michiquillay deposits is far in the future.

Several key personnel changes occurred in 1982. Pedro-Pablo Kuczynski resigned as minister of energy and mines, and joined First Boston Corporation in New York, New York, United States. He was replaced by Fernando Montero, who also became the president of the Consejo Intergubernamental de Países Exportadores de Cobre (Cipec). Guillermo Florez Pinedo resigned as president of Centromín, and was replaced by Felix Remy Alvarez Calderón.

SURINAM

The Surinam bauxite industry remains besieged by problems in both the short and long-term: soft prices, increased competition from Venezuela and Brazil, a dispute between the government and the country's two main producers over the bauxite production levy, and a stagnant exploration program.

Bauxite, alumina, and aluminum are Surninam's main exports. Last year they made up 80 percent of export earnings. The Suriname Aluminum Company (Suralco), a wholly-owned subsidiary of Alcoa and the country's largest producer, and Billiton Maatschappij Suriname, N. V., a subsidiary of the Royal Dutch Shell Group, account for almost all of Surinam's output. In 1982 they produced about 3,000,000 metric tons of bauxite, down from 4,230,000 tons in 1981 and 4,903,000 tons in 1980.

Billiton produced 1,700,000 tons of bauxite; Alcoa produced 1,470,975 tons of bauxite, 1,137,479 tons of alumina, and 41,484 tons of aluminum in 1982.

The government, which is concerned that bauxite mines will be depleted within the next 20 years, is encouraging development of new mines in the Bakhuys region. A 72-kilometer (45 miles) railroad from the port of Apoera to this western region has been built, but so far no development has taken place and the extent of reserves is being disputed. Construction of a dam at Kabalebo to provide hydroelectric power to new alumina and aluminum plants has been proposed.

The Surinam government is also interested in gold production. Australian geologist Eoin McDonald has been provided to Surinam under an Organization of American States technical assistance program, and began work on a reef gold project in Loksie Haiti.

VENEZUELA

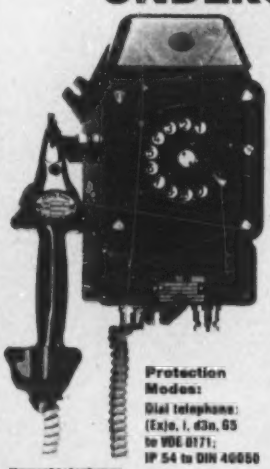
The $1,250,000,000 Interamericana de Alúmina (Interalúmina) refinery was about 95 percent complete by the end of 1982. Full capacity of 1,000,000 metric tons per year is scheduled for 1985. About 200,000 tons will be for export.

Bauxite will be imported from Brazil, Sierra Leone, Surinam, and Guyana until Los Pijiguaos, a domestic bauxite project, begins operations. Production at Los Pijiguaos is expected to be 1,000,000 tons per year beginning in 1986. Eventual production will be 3,000,000 tons per year. Reserves at Los Pijiguaos are 200,000,000 tons of ore grading 49.5 percent aluminum oxide, 7.5 percent free silica, and 1.8 percent reactive silica. When Los Pijiguaos goes on stream, Venezuela will have a fully integrated and self-sufficient aluminum industry.

Principal domestic customers for Interalúmina's production will be Aluminio del Caroni S. A. (Alcasa) and Venezolana de Aluminio (Venalum). Production at Alcasa was about 92,000 in 1982. Venalum produced approximately 175,000 tons of alumina, down from 202,000 tons in 1981.

C. V. G. Ferrominera Orinoco S. A. produced 11,866,651 in 1982, a drop from 14,929,356 tons in 1981. Sales were down to 10,553,000 tons, from the 1981 total of 14,878,933 tons. Domestic sales were up over 1,000,000 tons, up to 3,940,000 tons. Venezuela is developing the Cerro San Isidro iron ore deposit, which has 392,000,000 tons of estimated reserves of ore with an average grade of 65 percent Fe. Venezuela's total iron ore reserves are estimated at 2,131,000,000 tons.

ONSHORE - OFFSHORE - UNDERGROUND



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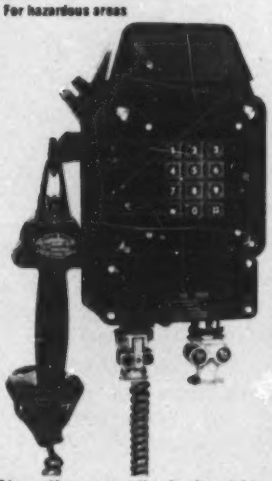

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FIJI

Western Mining Corporation Holdings Ltd. was considering buying a 20-percent interest in Emperor Gold Mines Ltd.'s Vatukoula gold mine and treatment facilities. Under the proposal, Western Mining would assume management of the operation.

Emperor Gold Mines' Empire mine is one of the few operating mines to process gold telluride ores. Production is about 27,000 ounces per year. The company is conducting a gold exploration program at the Big Mill prospect in the Tavu Basin, which adjoins the mine.

INDONESIA

Freeport Indonesia Inc. was one of the few copper producers in the world to make a profit in 1982. The company received the equivalent of $0.87 per pound of copper for the copper, gold, and silver values contained in its concentrates, compared to $1.07 in 1981.

Freeport Indonesia produced 82,800 tons of copper, compared to 66,120 tons in 1981, and 61,800 ounces of gold and 932,000 ounces of silver, up from 46,100 ounces of gold and 687,000 ounces of silver in 1981, at its Ertsberg open pit mine and Ertsberg East underground mine. Mill throughput was raised to over 10,000 tons of ore per day by year-end. Production is expected to be raised to 10,500 tons per day by mid-1983, and 12,000 tons per day by 1984. Higher mine, tramway, and mill throughputs are planned to compensate for gradually declining ore grades in the later 1980's.

The Ertsberg East mine reached the 6,000-ton per day level in January 1983, and will be progressively expanded. Drilling for additional high-grade reserves beneath the Ertsberg East ore body continues.

It now looks like P. T. Aneka Tambang's long-awaited Bintan Island alumina refinery will start-up in 1986.

Indonesian production of metals and minerals in metric tons

Commodity	1981	1982
Tin	27,780	26,210
Coal	350,350	480,980
Bauxite	1,203,380	700,256
Nickel ore	1,543,220	1,640,920
Ferronickel, nickel content	19,880	21,360
Nickel matte, nickel content	20,000	13,943
Iron sands	86,620	130,520
Copper concentrates	188,460	223,700
Gold, ounces	5,853	7,140
Silver, ounces	64,300	98,113

Klöckner Industrie-Anlagen GmbH will be the main contractor and Raymond Kaiser Engineers will manage the project. The refinery will initially produce 600,000 tons of alumina per year.

About 1,750,000 tons of bauxite will be needed annually to supply the plant. Aneka Tambang is reassessing the commercial value of West Kalimantan's bauxite deposits, which were extensively explored by P. T. Alcoa Minerals of Indonesia from 1969 to 1974. The refinery would supply Indonesian Aluminum Company's Anshan smelter.

P. T. International Nickel Indonesia, a majority-owned subsidiary of Inco Ltd., further reduced production at its Soroako nickel smelter. Only one electric furnace has been operating since February 1982. The facility has three furnaces and an annual production capacity of 75,000,000 to 85,000,000 pounds of nickel contained in a 75 percent matte.

Proven and probable laterite nickel reserves at the Soroako mine have been raised to 66,000,000 tons of ore containing 1,200,000 tons of nickel, up from 42,000,000 tons of ore with 800,000 tons of nickel.

In mid-1982, Jimberlana Minerals NL began looking for joint venture partners for its Mandor porphyry copper project near the west coast of Kalimantan. Soil sampling has indicated anomalous zones with copper values between 0.1 and 0.59 percent. Alluvial gold is also present. Jimberlana is conducting a drilling program to test the extent and grades of a suspected secondary enrichment zone, a chalcocite blanket.

NAURU

The government is working with India on several projects. The Paradeep Phosphates Ltd. joint venture has been established in the state of Orissa, India. Nauru is financing about $60,000,000 of the $230,000,000 joint venture fertilizer plant project. The plant will produce 300,000 tons of di-ammonium phosphate per year beginning in 1986.

Nauru produces about 2,000,000 tons of phosphate per year. However, reserves are expected to be exhausted within the decade.

NEW CALEDONIA

The Tiebaghi chromite mine and concentrate plant went on stream in 1982. Production at the mine will be 450 tons of ore per day. The operation is owned by Inco Metals Company (55 percent), Banque de Paris et des Pays Bas (22½ percent) and other French interests (22½ percent).

The country's largest nickel producer, Société Metallurgique Le Nickel, cut production at its Doniambo smelter from 44,000 tons in 1981 to 35,000 tons in 1982. Output in 1982 was 28,000 tons of ferronickel and 7,000 tons of nickel contained in matte.

NEW ZEALAND

Of the two beach sand magnetite concentration operations in 1982, New Zealand Steel Ltd. was the largest producer with 2,046,358 tons, compared with 2,162,260 tons in 1981 at its North Island operation. All the concentrate was used by the company as blast furnace feed at its Woolf Fisher steel plant in South Auckland.

The other beach sand miner was Waipipi Iron Sands Ltd., near Waverly on the North Island. Production totalled 900,495 tons of concentrate. Exports of slurried concentrate to Japanese steel mills were 898,495 tons.

PAPUA NEW GUINEA

Bougainville Copper Ltd.'s eleventh and twelfth ball mills were installed in 1982. Production was raised by 11 percent, to 41,740,000 metric tons of ore. Copper output rose 3 percent, to 170,004 tons, compared to 1981. Copper recovery was 87 percent, up 1 percent. Gold output increased 4 percent, to 563,525 ounces, but recovery dropped from 76 to 70 percent. Silver production increased 2 percent, to 1,387,369 ounces.

Copper and silver ore grades were down in 1982. The copper grade fell from 0.51 percent to 0.47 percent, and silver grade was down from 0.05 to 0.048 ounce per ton. The gold grade edged upward, from about 0.019 to 0.0193 ounce per ton.

The first stage of development of Ok Tedi Mining's copper and gold deposit at Mount Fubilan is scheduled to begin in March 1984. During this stage the deposit's gold-enriched cap, estimated to contain 34,300,000 tons of ore grading about 0.092 ounce gold per ton, will be mined. The primary deposit's reserves are estimated to be 377,000,000 tons of ore grading 0.72 percent copper, 0.012 percent molybdenum, and 0.020 ounce gold per ton.

About $850,000,000 of trade financing was secured in early 1982 from international export credit corporations, in-

ternational banks, and Ok Tedi's parent companies. Ok Tedi is owned by BHP Minerals of Australia, Amoco Minerals, Mt. Fubilan Development Company Ltd., and Kupferexplorationsgesellschaft GmbH.

Joint venture owners of the Porgera gold prospect have concluded that a number of problems must be overcome before the property can be developed. The rock is highly refractory, and less than 40 percent of the gold can be recovered by normal extraction processes. The deposit, 130 kilometers (80 miles) west of Mount Hagen, is also in an isolated location and will require an enormous amount of infrastructure.

Now being considered is a combined open pit and underground project to mine selected high-grade zones containing about 11,363,000 tons of material grading 0.21 ounce gold and 0.48 ounce silver per ton. Total reserves at Porgera are estimated at 59,000,000 tons of material grading 0.11 ounce gold and 0.46 ounce silver per ton at a cut-off grade of 0.05 ounce gold. The joint venture partners are Placer Development Ltd., Mount Isa Mines Ltd., and Renison Goldfields Consolidated Ltd.

Studies continued on a chrome-cobalt-nickel deposit at the Ramu River, 50 miles (80 kilometers) southwest of the port of Madang. The project is owned by MIM Holdings Ltd. of Australia and a group of United States companies, including Nord Resources Corporation and Highlands Energy Corporation. The three-layer laterite deposit has estimated reserves of 225,000,000 tons of wet material. The 10-foot (3-meter) top layer contains 107,000,000 tons of sandy, clay-type material of about 9 percent metallurgical grade chromite. The second, 9-foot (2.8-meter) layer is limonitic laterite, and reserves are about 81,500,000 tons of material grading 1.12 percent nickel, 0.16 percent cobalt, and 6 percent chromite.

Esso PNG, a subsidiary of Exxon Corporation, plans to spend up to $25,000,000 over five years in Papua New Guinea. Esso will concentrate its activities in the New Ireland and New Britain islands and the central highlands of the mainland.

Bougainville Copper Limited's operating results

Category	1980	1981	1982
Tons waste stripped	46,451,343	44,125,469	38,007,648
Tons ore milled	41,468,902	41,367,694	46,010,419
Average tons per day	115,171	114,916	127,807
Percent copper in feed	0.46	0.51	0.47
Total copper, tons	190,757	210,985	216,249
Ounce gold per ton	0.0145	0.0171	0.0174
Total gold, ounces	601,300	707,422	800,581
Ounce silver per ton	0.04283	0.04495	0.0429
Total silver, ounces	1,767,819	1,859,568	1,832,010
Copper recovery, percent	84.94	86.41	86.86
Gold recovery, percent	64.58	76.07	72.56
Silver recovery, percent	66.52	72.78	75.28
Concentrate recovered, tons	562,619	635,371	656,842
Concentrate recovered: ton per ton ore milled	0.01357	0.01536	0.01434
Copper in concentrate, percent	29.8	28.7	28.4
Gold in concentrates, ounces per ton	0.797	0.847	0.85
Silver in concentrate, ounces per ton	2.09	2.13	2.09
Total copper recovered, tons	162,032	182,322	187,393
Total gold recovered, ounces	448,407	538,158	560,866
Total silver recovered, ounces	1,375,874	1,353,340	1,379,070

PHILIPPINES

The Philippine government set up a $760,000,000 Copper Stabilization Fund in July 1982 to help the country's financially troubled copper companies. Companies could borrow money from the fund at 12 percent annual interest. When copper was sold at a higher price than it cost to produce, companies would pay the fund 10 percent of the difference between costs and sales.

Total copper production in the Philippines in 1982 was 292,787 metric tons, compared to 302,330 tons in 1981. Atlas Consolidated Mining & Development Corporation was the country's largest producer at about 144,000 tons. Because of low prices, only three out of the Philippines' 10 copper producers—Philex Mining Corporation, Benguet Consolidated Inc., and Lepanto Consolidated Mining Company—made a profit.

Philippine Associated Smelting and Refining Corporation's (Pasar) smelter and refinery was about two-thirds complete by the end 1982. Production will be about 110,000 tons of electrolytic copper and 28,000 tons of blister copper. Most of the production will be exported to Japan. By-product output will be 116,000 ounces of gold, 500,000 ounces of silver, 97,000 pounds of selenium, and 142,000 tons of sulphuric acid.

Philippine production of metals and minerals in metric tons

Mineral	1980	1981	1982
Gold[1]	654,405	758,290	834,421
Silver[1]	1,920,046	2,023,600	1,984,400
Copper	305,687	302,330	292,787
Cobalt	1,332	999	468
Chromite			
Refractory	340,460	283,419	178,948
Metallurgical[2]	92,802	138,548	112,597
Iron ore	2,957	5,746	5,573
Lead	1,782	1,068	—
Zinc	7,070	5,290	3,002
Molybdenum	88	94	80
Pyrite cinders	123,955	97,872	64,555
Manganese ores	500	3,113	1,556
Nickel, metal	25,382	21,494	11,302
Cement[4]	145,000,000[3]	135,000,000[3]	N.A.
Coal	400,000[3]	425,000[3]	N.A.
Barite	5,500	2,135	8,742

1. Fine ounces. 2. Concentrate plus ore. 3. Estimated. 4. Bags. 1.0 short ton = 0.907 metric ton. 1.0 metric ton = 1.10 short tons.

The National Development Company delayed the start-up of its Batong Buhay Gold Mines Inc. copper-gold-silver mine near Pasil Town. The delay was attributed to a postponement in the installation of power lines to the mine. The mine was resheduled to begin operations in mid-1983.

Primary and secondary gold production in 1982 was 834,421 ounces, up from 758,290 ounces in 1981. The largest producer was Benguet, at 236,000 ounces. Higher grade ore was milled and mill recovery was improved from 50 to 65 percent at Benguet's Dizon mines.

Benguet's Balatoc mill was expanded from 2,700 to 3,230 tons of ore per day in the first half of the year. Engineering for a future expansion to 3,750 tons per day was also completed.

Commercial dolomite production began at the Alcoy mine, 90 kilometers (55 miles) south of Cebu City. Dolomite Mining Corporation is the claim owner, and Philippine Mining Service Corporation, a Japanese joint venture, is the service contractor. Probable reserves are 230,000,000 tons of dolomite rock, of which 15,000,000 tons are proven.

SOLOMON ISLANDS

Mining here was confined to small scale alluvial gold working centered on the Gold Ridge area of Guadalcanal. A total of 41 kilograms of refined gold was produced in 1982. The alluvial gold originates from the Gold Ridge volcanics, which are hydrothermally altered andesitic breccias. In August the Solomon Islands government called for international tenders for the detailed prospecting and evaluation of the primary deposit. Work under a special prospecting license was due to commence in mid-1983.

Interest in other gold prospects, notably in the New Georgia area, was prompted by the work of the Western Solomons Mapping Project.

Apart from gold, several base metal anomalies have been discovered in an unusual suite of calc-alkaline volcanic rocks which appear to have resulted from the subduction of a spreading center.

The bauxite deposits of Rennell (25,000,000 metric tons) and Waghena (30,000,000 metric tons) aroused little international interest. Bulk samples, representative of both deposits, were submitted to a laboratory in West Germany for chemical and mineralogical tests to assess the possibility of blending Solomon Islands bauxite with other bauxites. This project is funded by the EEC.

UNITED STATES

ALASKA

The state's nonfuel mineral production in 1982 was valued at $115,000,000, according to preliminary information. This figure is approximately 10 percent below the final value reported for 1981.

Gold and silver were produced by an estimated 350 mechanized placer operations and several small lode mines. Large bucket-line dredges recovered gold near Nome, Hog River, and Nyac and one mined platinum near Goodnews Bay. Several smaller dredges mined gold on the Seward Peninsula and at Nyac.

Some of the larger mechanized placer mines have attained digging capacities equaling that of the large bucket-line dredges. The Independence, Little Squaw, and Grant Lode mines produced and milled gold and silver ores. The Independence Mine was equipped with a new mill rated at about 150 tons per day. Gold production in 1982 was 70,600 ounces; silver production was 19,560 ounces.

Minerals exploration and development expenditures were estimated at about $90,000,000. Most of the major mining companies continued exploration or development work on their claim groups in all districts in Alaska. The search for deposits for strategic minerals and precious metals accounted for a large part of the exploration expenditures.

Cominco American Inc. and NANA Regional Corporation Inc. announced the drilled reserves through 1981 at the Red Dog deposit, 90 miles north of Kotzebue, were 85,000,000 tons averaging 17.1 percent zinc, 5 percent lead, and 2.4 troy ounces of silver per ton.

Work at United States Borax and Chemical Corporation's Quartz Hill molybdenum deposit included starting a mine access road, environmental and engineering studies, and site evaluations. At Noranda's Greens Creek silver-gold-lead-zinc-copper project, some smaller deposits were drilled and studies were continued on access routes and possible mill and tailings disposal sites.

Alaska Apollo Gold Mines Ltd. began a surface and underground drilling program at its Apollo and Sitka gold mines on Unga Island in the Aleutians. Both mines were placed in operation in 1894 and closed down in 1906. Proven and probable reserves are estimated at 2,250,000 metric tons grading 4 percent lead, 3 percent zinc, 0.5 percent copper, 0.2 percent gold, and 5 ounces of silver per ton.

ARIZONA

Nonfuel mineral production value in Arizona for 1982 fell to $1,600,000,000 from the record $2,500,000,000 production value established in 1981; metals production provided $1,500,000,000 of the total value.

Once again, Arizona copper production ranked first in the nation and contributed more than one-half of the state's nonfuel mineral production, producing an estimated 815,522 tons valued at $1,211,755,000. In 1982, the industry sustained large losses in production caused by the decline in the market for copper, large inventories, the low price of the metal, and the resultant shutdown of many operations. In addition, its principal coproduct or byproduct, molybdenum, reached an oversupply situation and the market demand and price of molybdenum fell. The other byproducts of copper production, silver and gold, also slumped in quantity and value as a result of the reduction in copper output and lower prices for the metals during most of the year.

Virtually every major copper operation curtailed production. Mine closures during the year included Asarco's Silver Bell; Cities Service Company's Pinto Valley; Cyprus Pima Mining Company's Cyprus Pima; Duval's Esperanza and Mineral Park; Inspiration Consolidated Copper Company's Christmas; Kennecott Minerals Company's Ray; Magma Copper Company's Magma; Phelps Dodge Corporation's New Cornelia; and Ranchers Exploration and Development Corporation's Bluebird. A reduced work force and/or schedule was in effect most of the year at seven other operations. Only Cyprus Johnson Mining Company had no reduction in work force. Unemployment during the year peaked with about one-half of the people employed in the industry during normal times furloughed or layed-off.

In October, Phelps Dodge Corporation, having cut its inventories, resumed production at its Morenci and Metcalf operations and the Morenci smelter. Smelters on reduced schedules or which operated intermittently included facilities at Inspiration, Douglas, Hayden, and San Manuel; the Ajo smelter was closed in April. Asarco began preparations for the installation of a new Inco flash furnace at its Hayden smelter, which will assist it in attempting to meet state and federal air pollution requirements.

Anamax Mining Company placed its Twin Buttes and Helvetia properties on the market. Newmont Mining Corporation announced an agreement in principle to purchase the Cities Service Company's Pinto Valley, Miami, and Copper Cities properties.

ARKANSAS

Nonfuel mineral production in this state during 1982 was valued at $247,000,000. Arkansas continued to be a major

United States mine production of metals and minerals

Commodity	1978	1979	1980	1981	1982[1]
Gold[2]	965,084	970,000	951,348	1,280,000	1,226,533
Silver[2]	39,400,000	38,100,000	31,326,797	40,700,000	36,516,188
Copper[3]	1,358,000	1,444,000	1,109,239	1,699,500	1,256,500
Lead[3]	551,000	450,432	604,432	488,482	570,082
Zinc[3]	302,699	294,693	388,348	345,222	334,970
Coal[3]					
Anthracite	6,445,000	6,200,000	6,200,000	5,403,000	4,198,000
Other ranks	617,000,000	703,800,000	834,400,000	818,352,000	829,211,000
Asbestos[3]	93,000	93,000	80,000	83,600	70,400
Barite[3]	2,170,000	2,112,000	2,245,000	2,849,000	2,000,000
Boron[3]	778,436	799,000	783,000	740,000	585,000
Bauxite[4]	1,669,000	1,821,000	1,550,000	1,486,000	761,435
Nickel[5]	13,509	15,065	14,653	12,099	4,200
Vanadium[5]	8,544,000	11,040,000	9,612,000	10,252,000	9,400,000
Magnesium[3]	162,000	170,000	165,000	143,000	125,000
Sulphur[4,6]	11,180,000	11,470,000	11,484,000	11,724,000	9,503,000
Fluorspar conc.[3]	129,000	109,000	93,099	115,100	74,000
Tungsten[5]	6,901,000	6,646,000	6,036,000	7,815,000	3,200,000
Iron ore and conc.[4]	80,700,000	85,700,000	69,800,000	74,307,000	36,495,000
Molybdenum[5]	132,000,482	143,967,000	150,686,000	137,303,000	65,948,000
Phosphate rock[3]	50,037,000	51,611,000	59,840,000	58,482,000	41,223,000
Soda ash natural[3]	8,290,000	8,252,000	8,200,000	8,281,495	7,821,000
Potash, K_2O[3]	2,268,000	2,464,000	2,239,000	2,156,000	1,750,000
Uranium oxide[3]	15,000	18,730	21,850	19,140	13,000
Selenium[5]	508,636	587,118	310,588	554,548	535,714
Cadmium[5]	3,805,359	3,231,128	3,479,490	3,534,600	2,535,750
Cement[1,3]	82,000,000	84,800,000	75,730,707	72,932,000	62,515,000
Aluminum[3,8]	4,903,777	5,023,098	5,129,699	4,948,000	3,609,000
Mercury[5]	24,163	29,519	30,657	27,904	25,760

1. Preliminary, U.S. Bureau of Mines figures. 2. Fine ounces. 3. Short tons. 4. Long tons. 5. Pounds. 6. Frasch plus other. 8. Includes output from imported bauxite. 9. Flasks. N.A. Not available.

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producer of bauxite and bromine. Bauxite production was 663,400 metric tons, a nearly 50 percent decrease from 1981, valued at $14,800,000.

Reynolds Metals Company announced that it will close its Hurricane Creek alumina operation in August 1983, unless there is a sudden increase in the demand for aluminum. Union Carbide Corporation closed its Hot Springs vanadium mine and mill until July 1983 because of reduced vanadium demand. Dow Chemical Company resumed construction of its 120,000,000-pound-per-year calcium bromide solution plant.

CALIFORNIA

California was the nation's leading producer of nonfuel minerals for 1982. Value dropped to an estimate $1,700,000,000, a decrease of more than 15 percent from that reported in 1981. Much of the decline can be attributed to the slump in construction activity, as nearly all industrial mineral output was less in 1982 than in 1981. The state was the leading producer of asbestos, boron, diatomite, rare earths, and tungsten.

Kerr-McGee Chemical Corporation closed it 60-year old Trona plant. High energy costs were blamed for the closure although depressed markets for potash, sodium sulphate, and boric acid contributed to the problem. The company's neighboring plants (Argus and Westend) will continue production at reduced rates for anhydrous borax and boric acid; output of sodium sulphate is to remain at the level of previous years. United States Borax and Chemical Corporation, also citing declining boron sales, laid off employees.

Molycorp Inc. started production of high purity rare earth oxides from its new $15,000,000 separation plant at Mountain Pass.

United States iron ore, concentrate, and pellet shipments by companies and mines in gross tons

Company/Mine	1978	1979	1980	1981	1982
CF&I Steel Corporation					
Cedar City District[1]	802,836	730,588	708,333	71,905	—
Sunrise[2]	439,495	432,680	245,636	—	—
City Service Company					
Copperhill[3]	364,585	N.A.	N.A.	N.A.	N.A.
Cleveland-Cliffs Iron Company					
Cowles	612,691	586,331	720,767	916,984	—
Empire[4]	5,756,339	5,453,080	4,782,433	6,619,845[5]	3,448,504
Republic[6]	4,103,340	3,573,089	1,429,583	1,228,930	80,158
Pioneer[6]	1,439,823	1,127,395	132,600	52,728	80,158
Mather	97,500	82,357	22,656	—	—
Tilden[7]	3,879,793	4,658,043	7,424,961	6,583,903	3,837,913
Erie Mining Company (Pickands Mather & Co.)					
Erie[8]	9,128,000	9,472,070	6,102,290	15,122,488	3,654,704
Eveleth Taconite Company					
Fairlane[9]	4,803,574	5,584,171	5,334,675	5,834,943	3,974,497
Hibbing Taconite Company (Pickands Mather & Co.)					
Hibbing[9]	5,313,561	6,232,930	8,407,658	7,154,283	5,874,151
Hanna Mining Company					
Butler[1]	2,481,615	2,434,291	1,862,763	2,250,880	1,015,543
National[2]	4,836,427	6,587,013	2,7[illegible]3,237	2,665,298	2,038,190
Whitney	181,305	283,308	73,480	—	—
Groveland[2]	2,043,153	2,087,289	1,712,854	N.A.	40,078
Inland Steel Mining Company					
Sherwood	147,921	243,244	20,822	—	—
Minorca[2]	1,800,000	2,143,910	1,476,745	2,445,800	1,319,900
Jackson County Iron Company					
Black River Falls[2]	849,535	736,522	679,151	853,457	282,823
Jones & Laughlin Steel Corporation					
McKinley	973,700	877,575			
Benson Mines	—	—	727,000	483,138	616,750
Lind Greenway	—	—			
Hill Annex	987,746	52,850			
Kaiser Steel Corporation					
Eagle Mountain	1,834,342[2]	2,068,290[2]	1,191,481[2]	1,175,122[2]	283,104
	869,840[3]	800,720[3]	842,588[3]	643,681[3]	1,094,852
Total	2,504,196	2,869,010	2,034,069	2,948,410	1,256,857

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Homestake Mining Company filed its first application, in September, to begin construction on the McLaughlin mine. An environmental impact report was being compiled. Noranda Mining Company began production in October from its Grey Eagle gold-copper mine. Gulf & Western Industries Inc. continued to evaluate properties in Tuolumne County; the company has acquired mineral rights to 3,400 acres in the Mother Lode area.

Depressed tungsten markets caused Union Carbide Corporation to close its mine and mill near Bishop. The company reopened the mill in December to treat stockpiled ore; the mine remained closed.

California Nickel Corporation revealed construction plans for its $300,000,000 Gasquet Mountian mining and processing complex; the company plans to produce cobalt, nickel, and chromite.

COLORADO

The value of nonfuel mineral production in Colorado was estimated at $695,000,000. This was about one-half the peak value of two years ago and was primarily the result of the precipitous decline in molybdenum output. Production at Amax Inc.'s two large molybdenum mines, Climax and Henderson, which had held steady in 1981 despite the declining market, fell by nearly one-half in 1982. Both mines, which are among the nation's largest underground mines and produced 40 percent of the world's molybdenum, were temporarily shut down. The mines had accumulated a stockpile of concentrate amounting to one year's normal demand; Amax reported a

Company/Mine	1978	1979	1980	1981	1982
Meramac Mining Company					
Pea Ridge[1]	—	—	—	1,100,000	900,000
NL Industries, Inc.					
Tahawus[1]	365,000	N.A.	—	—	—
Pilot Knob Pellet Company					
Iron Mountain[1]	689,693	—	—	—	—
Pittsburgh Pacific Company					
Neville	8,972	—	—	—	—
Niles	1,043	—	—	10,689	—
Zeno	149,800	124,589	77,079	107,461	14,560
Donora	17,472	—	—	—	—
Knox Extension	19,560	12,406	—	—	—
Connie	75,373	94,806	49,440	59,986	5,053
Pillsbury Brown	1,331	—	—	—	—
Pittsburgh Pacific	18,807	—	33,907	42,706	45,008
Wyoming Annex	1,060	35,016	68,741	47,596	—
Algoma	76,450	—	29,147	17,150—	
Rochleau Annex	67,252	9,275	2975	37,980—	
South Sauntry	—	104,191	59,880	29,896	227
Silver	—	3,277	—	1,011	—
Gilbert	N.A.	N.A.	N.A.	2,836	—
Monroe	N.A.	N.A.	N.A.	13,853	—
South Toner	N.A.	N.A.	N.A.	1,497	—
Reserve Mining Company					
E.W. Davis[1]	9,149,029	9,500,000	4,390,070.	6,350,818	2,124,266
Rhude & Fryberger Inc.					1
Cross-Nelson	74,000	25,719	N.A	19,524	9,835
Hull-Rust-Day	34,546	9,704	N.A.	15,416	134
Rana	—	—	N.A.	295	76,514
Sharon	26,732	134,495	N.A.	71,230	64,066
Walsgm	102,978	1,152	N.A.	7,480	—
Snyder Mining Company					
Kramer	114,165	N.A.	N.A.	N.A.	—
United States Steel Corporation					
Mesabi[2]	12,377,579	16,456,390	14,411,700	12,525,210	3,404,657
Sherman	1,073,606	565,805	203,770	194,000	—
Rochleau	144,713	261,077	—	—	—
Arcturus	—	755,780	388,268	741,800	760
Plummer	1,173,500	—	—	—	—
Atlantic City[3,4]	1,710,000	1,638,000	1,680,000	1,744,000	1,056,228
Desert Mound[5]	811,800	387,000	245,600	640,000	202,315
Utah International Inc.					
Iron Springs	704,556	678,044	511,000	N.A.	N.A.

1. Preliminary. 2. Pellets. 3. Long Tons. 4. Net tons. 5. Ore. 6. Concentrate. N.A. Not available.

large operating loss for the year.

Output of all other metals, except gold, also fell significantly. In June, the Hecla-Day Mining Corporation closed the Sherman mine, the state's second largest producer of silver. Cripple Creek Victor Gold Mining Company, a joint venture of Texasgulf Inc., and Golden Cycle Corporation at Cripple Creek, reduced operations. The Union Carbide Corporation's uranium-vanadium mill at Uravan suspended production in mid-April and later postponed a scheduled September startup beyond year-end

FLORIDA

The value of nonfuel minerals production produced in Florida in 1982 decreased 26.8 percent to an estimated $1,300,000. Crushed stone, cement, and phosphate rock were the major commodities produced and accounted for the major portion of mineral value in 1982.

Phosphate production remained at a low level during the year, continuing a trend started late in 1981, and resulting in closure or reduction of output from many of the area's mines. The decrease in demand was caused by reduction in both domestic fertilizer sales and exports. During the year, 25 percent of the work force was unemployed, with nine mines and six plants temporarily shut down. At one point, the industry was operating at 30 percent of the 1980 level. Late in 1982, the industry was guardedly optimistic as inventories were reduced and some operations resumed production.

In spite of reduced demand for phosphate, expansion plans continued at most area operations, with scheduled start-ups for the mid to late 1980's.

Mississippi Chemical Company plans to develop a 3,000,000 ton-per-year mine and agreed to purchase phosphate rock from International Minerals & Chemical Corporation in exchange for phosphate rock reserves. Family Lines Rail Systems completed a $21,000,000 expansion of its Rockport export facility at Tampa, increasing capacity to 9,000,000 tons-per-year.

IDAHO

Idaho's nonfuel mineral production value for 1982 fell to an estimated $312,000,000 from a record $431,000,000 in 1981. Lower metal and nonmetal prices, coupled with mine shutdowns and permanent closures were the primary causes of the decline. Metal exploration expenditures during the year were estimated to be at their lowest level since 1975.

Shutdown of Bunker Hill Company's Kellogg complex was completed in October of 1982. Metal production ceased in July, an apparent end of a production record started in the 1890s.

Hecla Mining Company announced closure of the Star mine in June. The mine was the deepest lead-zinc mine in the United States; costs of deep mining and low silver values were the main reason for the closure. The company completed the merger of Day Mines, Inc. by fully integrating the Hecla Day Corporation into Hecla Mining Company.

Sunshine Mining Company suspended operations at the historic Sunshine mine in June and announced a reopening for December; a return to full production was scheduled for early 1983.

Preproduction work continued throughout the year at Cyprus Mining Corporation's Thompson Creek molybdenum mine. Overburden was being removed at a rate of 180,000 tons per day; mining will begin in mid-1983.

MICHIGAN

Estimated value of Michigan's nonfuel mineral production in 1982 was $979,100,000. For the third consecutive year, value of mineral production dropped because of the depressed economy and the slowdown in construction and manufactur-

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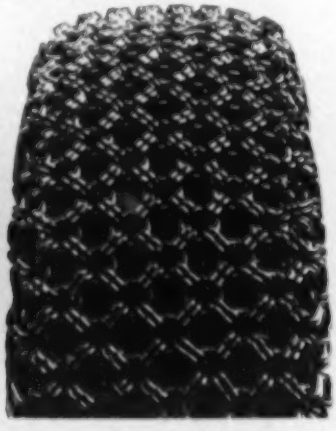

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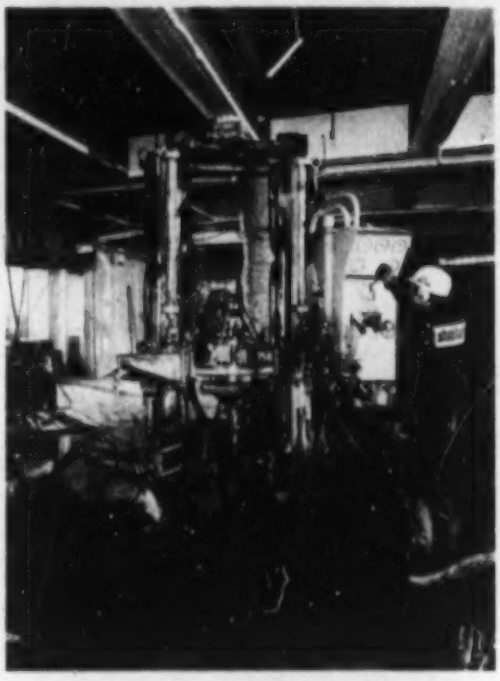

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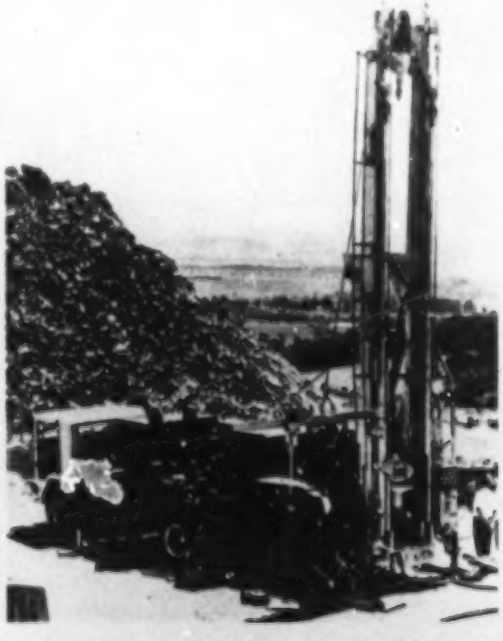

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ing. Both metallic and nonmetallic mineral producers were forced to halt production and lay off personnel because of high inventories and declining sales.

During the year, White Pine Copper, a division of Copper Range Company, announced several cutbacks in production at its mine and refinery complex in Ontonagon County and indefinitely suspended production operations on October 1, 1982 because of depressed market conditions and high costs. Work was essentially completed on the firm's new $80,000,000 electrolytic refinery, which had been under construction since the spring of 1980. In November, the firm announced it would begin processing high-grade copper scrap at the new refinery until market conditions improve.

Michigan's taconite industry also suffered setbacks during 1982. Cleveland-Cliffs Iron Company suspended production at the Empire and Tilden mines in May because of high inventories and reduced demand for pellets by the steel industry. Limited operations resumed at Tilden in September; several pellet lines were started up at both mines. The Republic mine remained shut down throughout the year.

In another action, Hanna Mining Company annouced it will permanently close its Groveland iron ore pellet operations near Iron Mountain. The Groveland operations had been closed since January 1981. Hanna had been trying to fine partners to take some of Groveland's 2,000,000-tons-per-year pellet production but without success.

MINNESOTA

Minnesota's mineral production in 1982 was valued at $1,176,600,000, a decrease of 45 percent from the record high set in 1981. The state ranked first in the nation in the value of iron ore produced and fifth in total nonfuel mineral production. Iron ore was the leading commodity in terms of value accounting for approximately 93 percent of the state total.

On the Mesabi Range, the year was marked by closures or production cutbacks at all taconite pellet production facilities due to the weakened demand for steel nationally. Taconite pellet production for the year amounted to approximately 36 percent of the annual production capacity of the state's eight plants. Shipment of usable iron ore in 1982 fell to the lowest level since 1938.

Near year-end, the Minnesota Department of Natural Resrouces held a copper-nickel exploration lease sale, involving approximately 1,000,000 acres of state-owned or administered lands.

MONTANA

According to the U. S. Bureau of Mines, estimated value of nonfuel mineral proudction in Montana for 1982 was $267,000,000, a decline of 12 percent from that reported in 1981. The decline was due to the reduction in nonmetal production, mostly clays. Metals accounted for 67 percent of the estimated total value.

Exploration activity in Montana decreased from previous years as a result of lower metal prices. Most new exploration and development involved precious metals. In spite of the decreased activity, however, there was an increase in the number of licenses granted by the state.

To mention a few of the 64 companies conducting exploration, both Asarco Inc. and United States Borax & Chemical Corporation were drilling in the Cabinet Mountains Wilderness for copper and silver; Noranda Exploration was evaluating silver-lead-zinc mineralization adjacent to the Nancy Lee mine northwest of Superior; Denison Mines Ltd. was exploring for precious and base metals north of Philipsburg; Cominco American, Exxon Minerals, and Molycorp Inc. were drilling for massive sulphide mineralization in the White Sulphur Springs area; and Hecla Mining Company and Gold Fields Mining Corporation were evaluating former gold producing areas in the north Mocassin Mountains.

Asarco's Troy Mines reached full production of 8,500 tons per day of copper-silver ore. Annual production was expected to reach 4,200,000 troy ounces of silver and 20,000 short tons of copper. The 48,000,000-ton ore body will allow mining to continue for 16 years. The Golden Sunlight mine of Placer Amax Inc., northeast of Whitehall, was scheduled to go into production in February 1983 with an initial mill capacity of 5,000 tons of ore per day. Reserves are estimated at nearly 26,000,000 tons of gold ore.

Anaconda Minerals Company stopped mining in the Berkeley Pit but continued to mine the East Berkeley Pit, processing 42,000 tons of copper-molybdenum ore daily through its Weed Concentrator.

Placer mining continued at a high level in western Montana. Small scale mining was widespread throughout Missoula, Mineral, Ravalli, Madison, Silver Bow, Powell, Broadwater, and Meagher counties. Most of the gold recovered from placer operations has not been reported.

The major new development in nonmetallics was Continental Lime's Indian Creek quarry and plant which began production in September. A new expanded talc sorting facility was under construction at the Cyprus Industrial Minerals Company's Yellowstone mine. Exploration for talc deposits continued at a high level in southwestern Montana.

NEVADA

Nevada's nonfuel minerals output value in 1982 was estimated to $467,000,000, a decrease of 8 percent from that recorded in 1981. The nation's declining economic climate had a dramatic effect on the state's mineral producing sector. Numerous mining operations were either placed on standby or suffered closures throughout the year.

Occidental Minerals Corporation closed its Candelaria open-pit silver mine in July because of low prices. Low prices also caused Silver King Mines, to shut down its Taylor mine operation near Ely; the company restarted the mine in the fall when silver prices rose. Houston International Minerals Corporation closed its Con-Imperial pit near Virginia City, and its Manhattan property in central Nevada.

The Anaconda Minerals Company ceased operations at its Nevada Moly mine for the summer. Operations resumed in early fall only to begin shutdown of the mill in November; operation of the leach plant continued. Anaconda also closed all operations at its Weed Heights facilities at Yerrington. At yearend, the company was evaluating sale bids for the property.

The collapse of the international tungsten markets caused the shutdown of Nevada's three largest tungsten mines: Union Carbide Corporation's Emerson mine, Utah International's Springer mine, and NRD Mining's Scheelite mine. Basic Incorporated, the sole magnesite producer in the United States, laid off half of its workforce in November because of poor demand in the steel industry.

Sunshine Mining Company dedicated its new "16-to-1" silver mine at Silver Peak. The underground mine is scheduled to produce 1,200,000 million ounces of silver annually.

Placer Amax Inc. approved placing into production its Horse Canyon gold deposit. The deposit reportedly contains 3,400,000 tons averaging 0.055 ounce of gold per ton. Production at 2,000-tons-per day should commence sometime in 1983. Cost of bringing the deposit into production is estimated at $7,000,000.

Newmont Mining Corporation completed purchase and lease agreements to insure access to its recently discovered Gold Quarry deposit near Carlin; the deposit has been reported to contain over 8,000,000 ounces of gold.

NEW MEXICO

Leading nonfuel minerals produced in New Mexico in 1982 were potash and copper, representing more than 51 percent of the state's estimated total nonfuel minerals production value of

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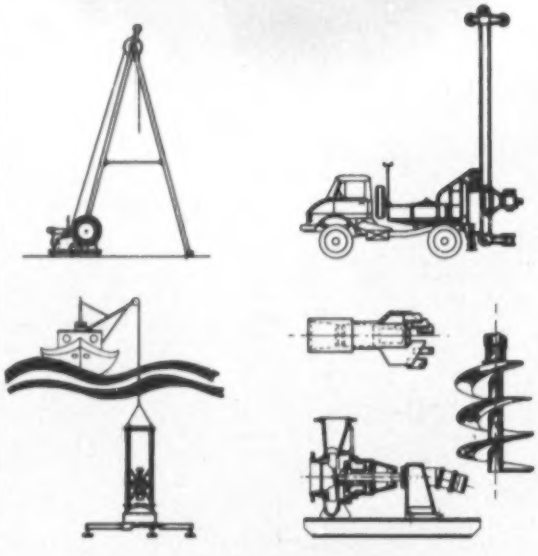

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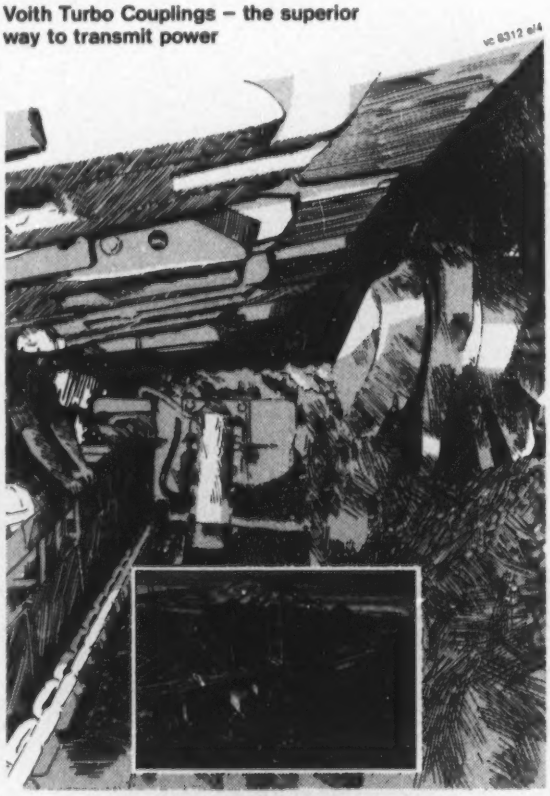

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$408,000,000. Aside from moderate increases in the production of gold and crushed stone all other mineral output declined, including a drop of about 5 percent in potash and 60 percent in copper.

The Kennecott Minerals Company and Mitsubishi Corporation partnership announced a $100,000,000-plus investment in the Hurley smelter to expand capacity and comply with environmental mandates. The partnership's new copper concentrator came on stream at the Chino Mines Division.

Molycorp Inc. closed its 18-year-old open pit molybdenum mine near Questa in August and planned to begin ore production from its new $250,000,000 underground mine at the site in July 1983.

Exxon Exploration planned to do geologic work on 300 base metal claims in the Burro Mountains during the winter 1982-1983. Conoco Company canceled its planned gold exploration program as the company phased out its minerals department following its merger with DuPont Company. Consolidated Gold Fields announced increased gold output from its Ortiz mine.

OREGON

The value of nonfuel mineral production in Oregon in 1982 was $110,000,000, a decline of 25 percent from that of 1981. Nonmetals accounted for the bulk of production value.

Hanna Mining Company, the sole nickel producer in the nation, suspended its Riddle operation in April after 28 years of production. Reasons given for suspension were increased power cost, low ore grade, and a slow market. The closure is expected to last at least through 1983.

Metals exploration continued but at a lower level than in 1981. In eastern Oregon, most of the activity took place in Baker and Grant Counties. The largest exploration venture was for gold by Brooks mineral at the North Pole Columbia Lode.

Other activities included United Nuclear Mining & Milling Services at the Cornucopia gold mine and Nerco at the Ibex and Bald Mountain gold mines. There was some proudction of gold noted at Veta Grande Corporation's placer property in the Mormon Basin. Other small operations with prouction in 1982 were the Pyx, Thomason, and Tempest gold mines. In southern Oregon, Noranda Exploration was drilling at the Turner-Albright mine for gold, copper, and cobalt, while Molycorp Inc. was exploring the Babcock property. Other activity for gold took place at the Ashland, Greenback, and Rainbow. Some exploration was also noted in the old Bohemia district. Amoco minerals continued exploring for sulphide mineralization in the Western Cascades Volcanic rocks.

SOUTH DAKOTA

Gold accounted for 56 percent of the state total mineral production value in 1982, representing $81,174,000 of the state's total of $144,800,000. This total represents a decrease of 25 percent from that of the previous year. A principal factor contributing to the 1982 decline in mineral production value from that of 1981 was the sharp drop both in the gold price and production level. The price of gold dropped an average of $63.00 per troy ounce from the 1981 level and the quantity produced was the least since 1907 (except for a short period during World War II).

The year was marked by a 5-month strike by miners at the Homestake Mining Company'sgold mine at Lead. Near midyear, Homestake announced plans for an open pit gold mine at a location near the surface facilities of its current underground mine. The site was the original gold discovery area and was mined to shallow depths by both open pit and underground methods in earlier years. Homestake tentatively plans to crush the ore at the mine, then haul it to its nearby mill for processing.

TENNESSEE

In 1982, the state continued to be the nation's leading producer of zinc, ball clay, and pyrite. Total value of nonfuel mineral production was $381,000,000—$36,000,000 below the record set in 1981.

In August, Consolidated Aluminum Corporation (Conalco) shut down 75 percent of the last remaining potline at its New Johnsonville primary aluminum smelter, reducing capacity to 9,125 tons per year, or less than 10 percent of annual rated capacity. Aluminum Company of America (Alcoa) shut down a 55,000-ton-per-year potline at it's Alcoa plant.

Depressed zinc markets and high operating costs were contributing factors in several zinc mines closing during the year. In May, Gulf and Western closed the Jefferson City mine. The company announced the closure of its Beaver Creek mine in June; however, approval by union workers of a 22 percent wage cut and other concessions resulted in a guarantee that Gulf and Western would continue to operate the facilites until the end of the year. In October, United States Steel Corporation shut down its zinc mine operations at Jefferson City, following rejection by union workers of company-sought concessions.

UTAH

Nonfuel mineral production value for 1982 in the state of Utah fell to $627,000,000. The total value of metal output dropped to $471,000,000 and accounted for three-fourths of the state's total value of nonfuel mineral production.

Copper output represented nearly two-thirds of the metals produced in the state, despite a downturn in the industry caused by low market demand, large inventories, and low prices of copper. The state produced 188,481 metric tons at a value of $307,000,492. Output of byproduct metals—molybdenum, gold, and silver—also fell. Utah's largest private employer, Kennecott minerals Company, laid off approximately 1,950 workers at its Utah Copper Division. In late November, the company closed its Trixie mine in the East Tintic mining district. In October, Anaconda minerals Company announced the gradual shutdown of its Carr Fork mine near Tooele.

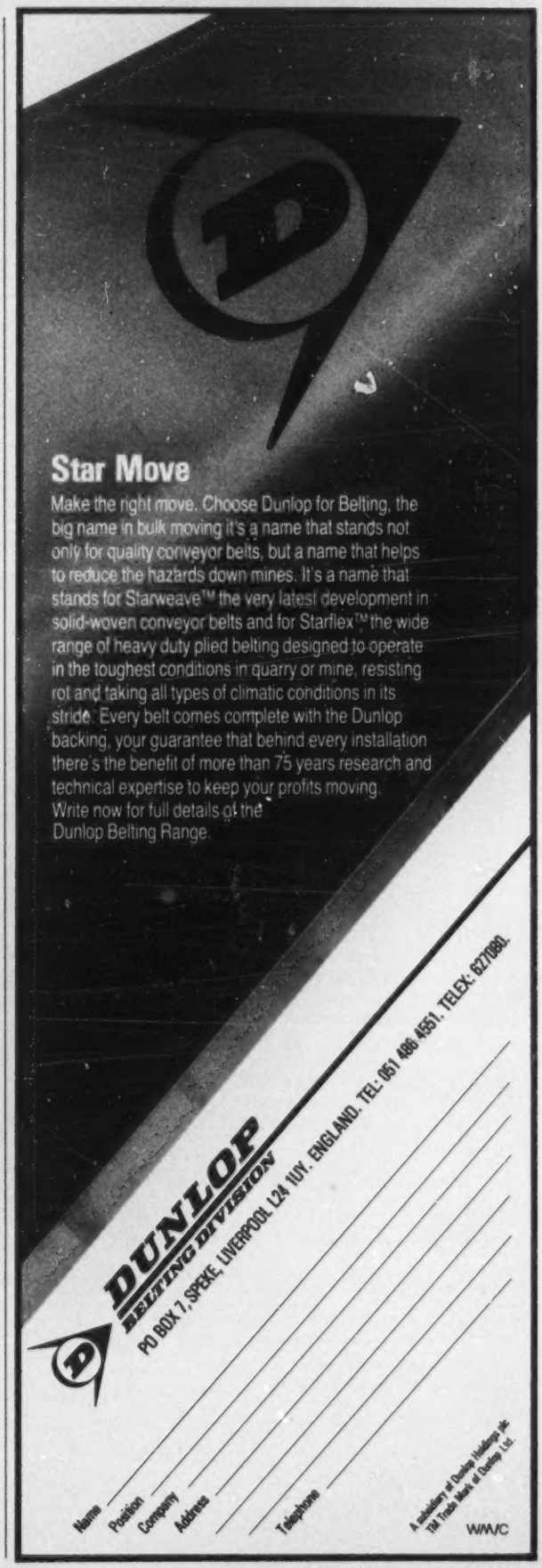
Other developments contributing to lower metal production included the shutdown of the Ontario silver-lead-zinc mine and the termination of its lease with the United Park City Mines Company, leaving the Park City mining district without any operating mines. United States Steel laid off workers at its Genevea Works near Provo; Atlas Minerals Corporation cut back mine and mill workers at its uranium-vanadium operations near Moab; and Union Carbide Corporation laid off workers at its uranium vanadium operations in San Juan County.

Several new projects were placed into production or continued in the development stage during the year. Rancher's Exploration and Development Corporation brought its Escalante underground silver mine on stream at the end of 1981; by June 30, 1982 production totaled 1,100,000 million ounces of silver. Getty Mining continued construction of its open pit gold mining operation at Mercur. Scheduled for production in June of 1983, the $80,000,000 operation is planned to produce 80,000 ounces of gold per year. Its expected life is 14 years.

WASHINGTON

Estimated value of Washington's nonfuel mineral production in 1982 was $183,000,000, a decline of 14 percent from the $212,478,000 total recorded for 1981. This decline is a reflection of the overall national trend. Exploration and development activity were down slightly from that of 1981. The bulk of the exploration was for gold and silver, followed by copper, molybdenum, lead, and zinc.

The state continued to rank first in quantity and value of primary aluminum production although the weakened economy and increased energy costs continued to take their toll on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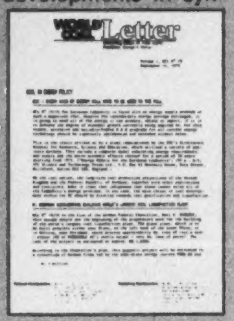

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the industry. A number of potlines were closed during the year and the modernization program by Kaiser Aluminum and Chemical Corporation was in jeopardy. The company reduced production at its Mead smelter and closed a fourth primary potline, bringing production down to 110,000 tons—50 percent of full capacity. Year-end production in the state was at 70 percent of total operating capacity, with only two of seven plants operating at full capacity.

Barite was of considerable interest in the northeastern part of Washington, with four companies at various stages of project development. Two new projects were in operation at the beginning of the year, a third was planned, and drilling and exploration were taking place at a fourth site.

The Madre Mining Corporation began producing silver at its Deer Trail Mine near Fruitland. Newly-mined ore was mixed with stockpiled ore going to the mill to increase the ore grade. Stockpiled ore contains about 13 ounces of silver per ton but the company reported that estimates indicated the newly-mined ore contained an average of 25 ounces per ton.

International Titanium Inc. started to produce titanium in April, although at somewhat less than its rated capacity.

WISCONSIN

Estimated value of the state's nonfuel mineral production in 1982 was $123,400,000. The weakened state of the economy continued to negatively affect the state's mineral producers throughout the year.

In April of 1982, Wisconsin's sole metallic mineral producer, Jackson County Iron Ore Company, closed its taconite operation in Black River Falls. The mine and plant remained closed for the rest of the year due to the reduced demand for steel.

Exxon Minerals Company continued environmental and engineering studies on the 70,000,000-ton Crandon zinc-copper deposit. At year-end, the company submitted an environmental impact report and began to apply for the necessary state and federal permits for mining. This process is expected to take about two years, after which Exxon will decide whether to go ahead with mine construction.

WYOMING

The value of nonfuel mineral production in Wyoming in 1982 was estimated to be $719,000,000. Sodium carbonate and bentonite continued to be the major nonfuel minerals in the state; Wyoming is the nation's foremost producer of these commodities.

United States Steel Corporation's Atlantic City iron ore mine was shut down from June 6 to August 22, and again from mid-September to October 26 due to the poor economic condition of the steel industry. The mine added equipment to crush waste rock into aggregate for sale to railroads and construction companies.

A depressed soda ash market was manifested in a work force reduction during the year of nearly 10 percent of the workers employed in the trona mining/soda ash refining industry in the southwest part of the state. Of the four established trona mine/soda ash plants in the area, only Stauffer Chemical Company of Wyoming did not follow this trend.

Despite these facts, Tenneco Oil Company proceeded with the official opening of its 1,000,000-ton-per-year trona mine and soda ash processing plant, becoming the fifth such operation in the Green River area. FMC Corporation, Allied Chemical Company, and Vulcan Materials Company, continued their research programs for the solution mining of trona.

Following announcement early in the year by the Wyoming Geological Survey of discovery of "significant" gold deposits "somewhere" in the state, Timberline Minerals, Inc. bought or leased 1,800 acres in the Seminoe Mountains, where preliminary investigation indicated a gold resource with a content of about 0.277 ounces of gold per ton.

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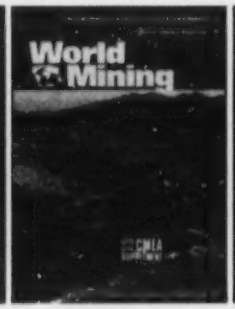

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THE COVER

Bingham Canyon is the world's largest man-made excavation. This month, WORLD MINING takes a look at this important United States open pit copper mine. Also presented are two special reports, one on continuous miners and roadheaders, another on two important facets of the Australian minerals industry. *Photograph by Kennecott Corporation.*

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Cominco Ltd.	91	Hindustan Copper	95	Nord Resources	94		

The world's premier producer of heavy mineral sands has been losing share of market on a worldwide basis. Emphasis on developing inland reserves may change this. Allied Eneabba is one company contributing to the effort

Australian mineral sands industry update

By **Leo A. Lyons**
Australasian Editor

Australia's "black sands" were first exploited—for gold—over a century ago on the north coast of New South Wales. A small gold production with negligible platinum and tin continued for more than 50 years, for it was not until the 1930's that the real interest developed in the rutile and zircon contents of the sands. This then resulted in Australia becoming the world's premier supplier of those minerals. Table 1, below, shows Australian heavy sands reserves at the end of the year 1980.

There are two broad areas of economic importance in the country:

- East coast from north Brisbane to Newcastles; and
- Areas (old coastlines) slightly inland from present shorelines north and south of Perth (see Figure 1).

Approximately one-third of the total ilmenite, two-thirds of the rutile, and 40 percent of the zircon are in the east (see Table 2). However, due to a small chromium content, the eastern ilmenite is unsuitable for pigment manufacture. In addition, 30 percent of the eastern rutile and 20 percent of the zircon is "frozen" in the east due to an environmental decision.

To a considerable degree, practices and equipment for sand mining and separation have been developed and manufactured in Australia. Heavy mineral contents of sands mined initially on eastern surf beaches were 5 percent or more (very roughly one third each of ilmenite,

Table 1. Australian heavy sands reserves (million tons)

Mineral	Demonstrated	Inferred	Subeconomic	Total
Ilmenite	43.3	0.51	18.5	62.31
Monazite[1]	332.6	3.50	158.70	494.80
Rutile	8.99	0.25	1.99	11.23
Zircon	12.94	0.24	4.31	17.49
Total	85.53	1.00	24.98	91.53

1. Thousand tons.

Figure 1

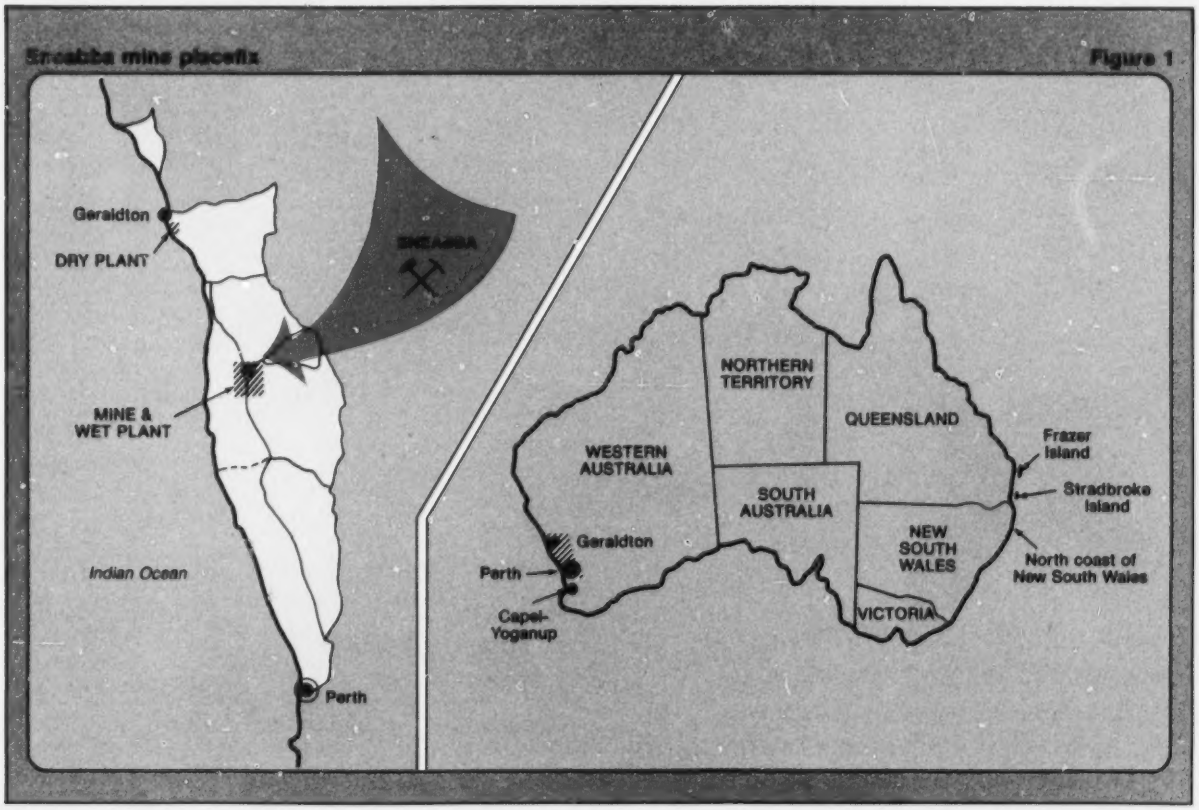


Table 2.
Heavy mineral reserves[1] by region

	Eastern	Western	Total
Rutile	6.1	3.1	9.2
Zircon	5.7	7.7	13.4
Ilmenite	13.7	29.1	42.8

1. Million tons.

rutile, and zircon, but varying from place to place.) Today, very large tonnages must be handled by suction dredges to maintain profitable production from deposits containing perhaps 0.5 percent of total heavy minerals.

As shown in Table 3, Australia's status as the world's premier producer of rutile and zircon has declined due to increasing costs relative to those of competitors, the "freezing" of reserves in rich eastern deposits, and increased output.

For the above reasons and also because of increasing world demand for ilmenite, it was inevitable that increasing emphasis was and will continue to be placed on Western Australian production despite the fact that eastern output is expected to continue for some years, especially from high dunes. Western ilmenite is satisfactory for pigment manufacture, but the rutile and zircon require more meticulous cleaning than in the east.

Allied Eneabba Operations

The mine and separation plant of Allied Eneabba Ltd., recently visited by this editor, is an excellent example of flexible and efficient adaptation to circumstances. By special enactment, mining operations are within a national park. The preservation and restoration of environment shows that mining can be undertaken without detriment to the unique flora and fauna.

The Eneabba area is some 280 kilometers (170 miles) north of Perth and was only recognized as an important mineralized zone in 1972. At the present time, it is estimated to contain more than 40,000,000 tons of heavy minerals in an area of 120 square kilometers (46 square miles).

Allied's reserves at the end of 1982 contained 8,260,000 tons proved and 4,448,000 tons probable heavy minerals, but additional reserves will be proved as exploration and definition continue. Heavy mineral concentration in the ore is around 10 percent and, while there are variations in different parts of the leases held enabling some flexibility to increase or decrease output of a particular product short term, the nominal separation plant capactiy indicated likely average contents of the several minerals as follows:

- Ilmenite: 250,000 tons per year
- Rutile: 50,000 tons per year
- Zircon: 120,000 tons per year
- Monzonite: 10,000 tons per year.

Kyanite production has now commenced and satisfactory demand is indicated.

Ore mined at Eneabba amounts to approximately 6,000,000 tons per year. The deposits are relatively soft and to maximum depths of about 8 meters (26 feet). Mining equipment includes scrapers and dozers. Contractors undertake this work on a long term basis.

Leases cover 15 kilometers (9 miles) north to south around the plant and 10 kilometers (6 miles) east to west. Three conveyors were recently installed to eliminate off-highway dump trucks, 1.2 kilometers (0.7 mile) west of the bulk separation plant and two totalling 3.6 kilometers (2.2 miles) east and north (see Figure 2).

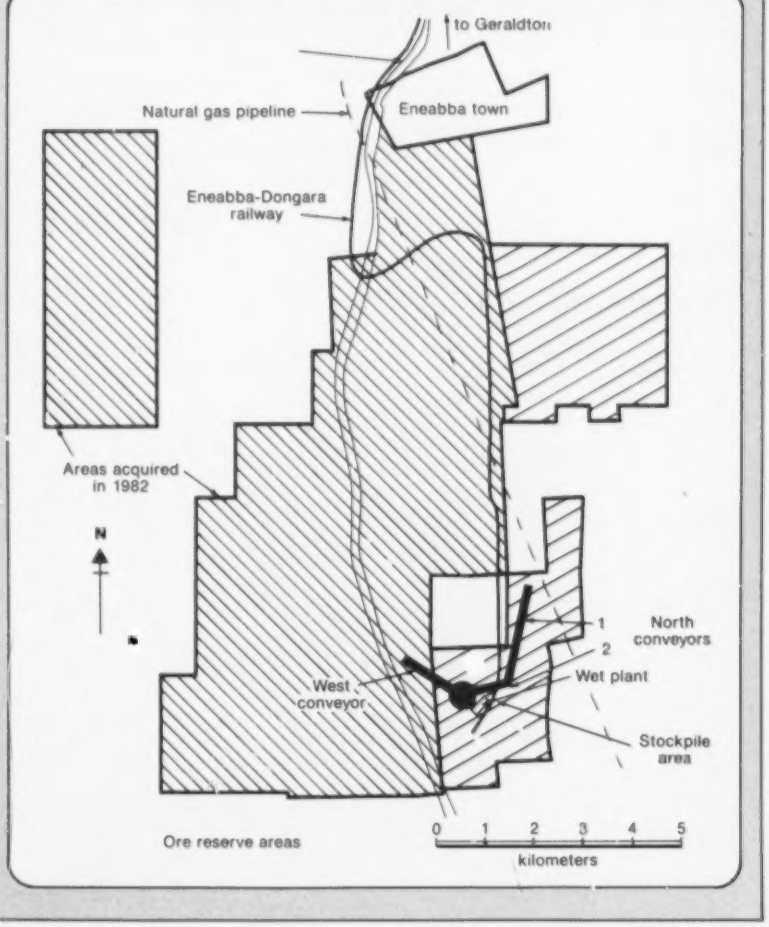
Table 3. Zircon & rutile production[1]

Zircon	1976	1982
World	530	627
Australia:		
(east)	286	153
(west)	134	290
Total	420	443
Rutile		
World	429	350
Australia:		
(east)	308	144
(west)	82	74
Total	390	218

1. Million tons.

The conveyors supply ore to a buffer stockpile from which it is recovered by a bucketwheel reclaimer as plant raw feed material. The product, approximately 96 percent heavy minerals, is railed to the separation plant at Narngulu near Geraldton, the port from which shipment takes place. ■

Plan view of Allied holdings and conveyor configuration **Figure 2**



Low prices, small demand, use of substitution, high production costs, cheap foreign production, increased imports, slowing annual growth rates—an age of diminution

United States open pit and underground mine tonnages

By **George O. Argall, Jr.**
Senior Editor

It is very well-known that the United States mining industry had one of its lowest production years in recent times in 1982. A check of the underground and open pit mine tonnage tables included with this article will quickly indicate just how low this production was in comparison with earlier years. Profits for the year were even worse for many of the operating companies. Several major copper companies as well as non-metallic mining companies continued production, often at limited scale, because it was cheaper for them to mine their own metals than to buy metals on the market to fulfill sales contracts. These were direct production costs and did not include costs of replacing the metals.

At year end many mines were closed and some had been for several months. At other companies, many mines were closed and it was not unusual to have a company operating only one, and the lowest cost producer, of its mines.

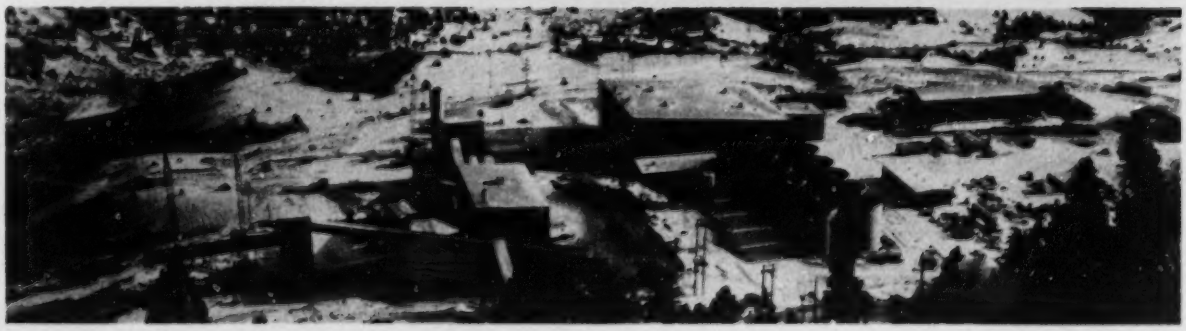
Low production measured in tons of ore mined directly resulted in smaller United States production of every major and many minor metals and nonmetallics. Gold output was down marginally while coal output was up marginally. Greatest decline in production was in molybdenum, tungsten, nickel, and iron ore. With the United States steel industry only operating at 50 percent of capacity for long periods of the year, the lower production of iron ore is clearly evident. And molybdenum, tungsten, and nickel uses are largely dependent on the tonnage of alloy steels produced. The only nickel mine in the United States, the Riddle, Oregon mine of the Hanna Mining Company suspended its operation in April 1982 after 28 years of production. The closure is expected to last through 1983. Nickel demand on a global basis was so low that the world's largest producer, Inco Ltd. in Canada closed its mines for most of the year.

Many Reasons for Low Output

The troubles of the mining industry were basically due to the small demand for metals. The great surge in exploration, successful exploration, in the last decade, and the much too optimistic forecasts for accelerating metals uses a resulted in a magnificent production base—from developed mines through smelting and refining capacities.

Much of the latter was becoming environmentally acceptable after the expenditure of several billions of dollars in the United States. These investments, generally, did not reflect any increases in capacities. Production capacity was in place bit certainly not utilized.

Low demand resulted in low prices



THE LARGEST open pit was Kennecott Minerals Company's Utah Division, shown at right, where 36,878,000 tons of ore were mined. **BELOW,** the mill at Placer's new Golden Sunlight open pit gold mine near Butte, Montana. Annual production is expected to be 2,250,000 grams.

Short tons of ore mined from United States underground mines

Company	Mine	1975	1976	1977	1978	1979	1980	1981	1982
Amax Chemical Corp.	Carlsbad Potash	2,888,139	3,000,000	3,497,000	3,454,381	3,563,732	3,021,546	4,130,347	4,176,834
Amax Lead Company of Missouri[a]	Buick	1,634,000	1,614,000	1,612,082	1,440,216	1,880,857	1,653,752	881,127	2,264,000
Amax Inc.	Climax	11,035,470	12,069,670	11,009,670	16,484,000	9,836,705	10,187,406	10,792,897	3,508,000[e]
	Henderson	—	650,014	4,543,000	6,933,400	9,382,415	10,327,374	9,737,037	3,851,207[e]
Asarco Inc.	Galena	176,399	182,272	177,704	176,782	181,040	192,000	197,000	201,877
	Coeur	—	41,976	146,924	151,900	156,000	165,000	184,000	134,840
	Ground Hog	122,703	130,680	135,986	46,743	—	—	—	—
	Leadville	200,170	199,920	186,000	189,000	173,900	202,000	200,000	212,640
	Tennessee Mines Total	1,984,555	1,832,885	2,019,857	1,838,160	1,824,530	2,088,000	2,085,000	2,000,000[e]
	Troy	—	—	—	—	—	—	577,000[e]	2,700,000
Atlas Minerals	Total	N.A.	N.A.	N.A.	N.A.	374,316	296,508	N.A.	N.A.
Bethlehem Mines Corp.	Grace Mine	2,118,727	2,091,535	1,112,575[e]	—	—	—	—	—
Bunker Hill Company	Bunker Hill	711,130	818,897	456,000	546,572	530,796	535,051	661,361[e]	—
	Crescent	30,987	26,465	15,000	31,343	34,932	35,078	25,380	N.A.
	Pend Oreille	306,184	380,581	154,000	—	—	—	—	—
Cities Service Co.	Calloway	400,001	378,980	273,541	449,000	440,000	435,000	N.A.	N.A.
	Boyd	349,757	368,400	196,711	280,000	234,000	192,000	N.A.	N.A.
	Cherokee/School Property	856,292	1,159,863	843,105	958,000	1,049,000	1,012,000	N.A.	N.A.
Clayton Silver Mines Company	Clayton	79,807	91,061	N.A.	N.A.	N.A.	51,932	38,250	23,696
Cleveland Cliffs Iron Co.	Mather	1,957,000	1,671,000	1,114,000	1,804,000	1,082,000	—	—	—
C.F. & I. Steel Corp.	Sunrise	476,570	385,421	372,603	438,405	432,680	245,636	—[e]	—
Cominco American, Inc.	Brock/Warm Springs	N.A.	191,000	162,000	184,000	192,000	202,000	201,000	186,000[e]
	Magmont (50% Cominco)	1,000,000	1,070,000	1,094,000	1,050,000	1,066,000	1,094,000	1,127,000	1,107,000
Cyprus Mines Corp.	Bruce Mine Division	94,606	90,278	40,710[e]	—	—	—	—	—
Diamond Crystal Salt	Jefferson Island	N.A.	1,400,000	1,253,000	1,406,997	1,400,139[e]	1,311,709	—[e]	—
	Akron[a]	—	—	241,149	235,883	235,000	N.A.	N.A.	N.A.
	St. Clair[a]	—	—	305,350	322,706	368,000	N.A.	N.A.	N.A.
Duval Corp.	Nash Draw	2,295,693	2,135,941	1,115,222	946,500	882,000	955,800	1,056,000	821,000
	North	—	21,461	640,000	1,077,021	485,000	—	—	—
Eagle-Picher Industries, Inc.[a]	Shullsburg	260,123	268,000	308,000	164,300	—	—	—	—
	Boarhole[a]	132,980	158,000	295,000	37,000	—	—	—	—
Exxon Minerals Company	Highland	—	—	70,000	138,843	131,300	135,700	98,000[e]	128,500[e]
FMC Corp.	Green River-Trona	3,600,000	4,194,000	4,703,000	4,594,000	4,820,000	4,822,300	5,005,000	4,062,000
Federal Resources Corp.	Camp Bird	104,300	82,970	27,150	14,634	—	26,305	—	—
	Meda Weeks	—	82,319	295,088	N.A.	388,388	387,000	N.A.	N.A.
Hecla Mining Co.	Grayrock	22,110	19,533	21,027	3,328	—	—	—	—
	Lucky Friday	173,245	186,520	182,412	158,000	175,900	188,340	148,884	210,870
	Star Unit	282,161	282,037	283,484	280,299	264,113	281,856	151,670	128,647
	Sunshine Unit	62,034	13,447[e]	44,024[e]	—	153,714	42,900	51,845[e]	77,401
	Sherman	—	28,89	53,514	86,900	98,540	97,461	N.A.	243
	Republic	—	—	—	—	23,815	43,947	62,710	58,630
	Victoria	—	—	—	—	—	—	124,575	N.A.
Homestake Mining Co.	Homestake	1,473,382	1,656,442	1,580,206	1,508,540	1,429,000	1,706,521	1,648,803	1,150,000
	United Nuclear-Homestake	325,950	461,140	334,113	540,147	705,200	2,107,504	344,001	N.A.
	Bulldog Mountain	104,470	117,783	113,672	110,305	97,438	100,579	103,609	80,149
	Grants Mines	—	—	—	—	—	809,250	377,537	240,092
	Pitch Mine	—	—	—	—	—	78,740	44,829	27,364
Howe Mining Co.	Howe	574,524	361,250	388,750	198,650	—	—	—	—
Inland Steel Co.	Sherwood	277,848	705,000[e]	386,798	215,588	—	—	—	—
Inspiration Consolidated Copper Co.	Black Pine	54,000	68,000	64,000	77,000	74,000	N.A.	N.A.	202,371
International Minerals & Chemical Corp.	Carlsbad	4,644,000	4,837,000	5,000,000	4,980,582	5,000,000	5,000,000	5,500,000	750,000
Kennecott Copper Corp.	Tintic	175,000	331,775	—	—	—	—	—	—
Kerramerican, Inc.	Blue Hill	211,211	176,079	143,598[e]	—	—	—	—	—
Kerr McGee Corp.	New Mexico Potash	2,150,000	2,150,000	N.A.	3,108,456	3,071,788	894,000	647,000	800,000
	Ambrosia Lake	980,531	900,000	1,000,000	1,165,610	1,173,828	1,500,450	1,562,860	1,000,000[e]
Magma Copper Company	San Manuel	16,778,247	15,011,111	17,000,000	19,638,032	21,826,005	13,803,270[e]	22,197,550	10,204,105
	Superior	955,943	971,313	1,034,563	988,837	973,200	556,940[e]	1,021,951	638,859[e]
Meramec Mining Co.	Pea Ridge	2,051,793	2,000,056	2,062,543	—[e]	755,000	1,236,000	1,095,104	1,241,021
National Potash Co.	Eddy	1,684,428	1,000,000	—	—	—	—	—	—
	Lea	73,922	270,000	1,000,648	1,708,111	1,903,304	1,705,000	—	—
New Jersey Zinc Co.	Eagle	208,232	176,648	179,648	167,5[illegible]	—	—	—	—
	Jefferson City	390,628	431,435	442,834	430,000[e]	453,870	480,488	N.A.	N.A.
	Austinville	640,000	546,516	533,350	460,563	490,635	531,738	—[e]	—
	Friedensville	450,000	479,477	519,580	494,647	520,683	527,041	541,033	N.A.
	Sterling	180,587	207,329	207,790	191,900	200,000	200,926	113,000	180,000
	Elmwood	180,500	405,413	639,581	600,000[e]	494,291	N.A.	N.A.	N.A.
Noranda Mines Ltd.[a]	Lakeshore	—	—	1,279,283	1,216,000	—	772,000	1,766,000	1,622,000
Ozark Lead Co.	Sweetwater	1,338,269	1,388,286	1,490,000	1,435,308	1,040,156	1,625,353	1,680,000	1,429,000
Pathfinder Mines Corp.	Big Eagle	—	—	—	—	—	—	24,591	42,458
	Lucky Mc	—	11,000	7,000	19,000	18,027	13,924	18,867	10,503
	Shirley Basin	—	—	—	—	—	—	—	4,411
Phil Kerr Potash Co.	Phil Kerr Potash	1,999,000	1,991,000	1,748,000	1,741,542	1,753,000	—[e]	—	—

Company	Mine	1975	1976	1977	1978	1979	1980	1981	1982
[illegible]	Escalante	—	—	—	—	—	—	—	230,400
	Hope Mine	—	80,000	38,883	65,152	48,840	29,572	—[3]	—
	Johnny M.	—	35,400	108,220	176,850	157,422	164,010	—[3]	—
[illegible]	Salmo County	76,000	80,000[4]	—	—	—	—	—	—
[illegible]	Lisbon	254,523	[illegible]320	273,527	262,005	274,476	270,093	238,026	147,452
[illegible]	J. J. No. 1	—	—	164,200	262,000	156,000	243,000	N.A.	N.A.
St. Joe Resources Company	Balmat	1,246,733	1,239,456	1,194,510	433,163	158,000[5]	67,142	561,957	604,119
	Brushy Creek Division	1,139,632		1,220,202	1,262,005	1,234,679	1,208,353		
	Indian Creek Division	606,550	4,813,182	651,802	481,176	675,431	637,598	3,812,087	3,800,000
	Viburnum Division	1,716,357		1,275,122	1,271,484	1,589,576	1,124,513		
	Fletcher Division	1,085,252		1,021,881	1,987,778	1,540,670	1,228,049		
	Flamgard	—	—	—	—	—	—	—	200,000[6]
[illegible]	Sunnyside	210,000	224,844	205,217	122,702	—	119,705	28,000	225,000
[illegible]	White Eagle	—	—	573	1,183	1,183	—	—	—
[illegible]	Big Island	2,400,000	2,618,000	2,620,000	3,000,000	3,000,000	2,783,036	2,779,736	2,256,000
[illegible]	Sunshine	225,897	45,600	155,116	200,850	172,220	58,961[10]	197,154	104,500
	16-1	—	—	—	—	—	—	—	138,158
[illegible]	Granger	—	140,000	650,000	1,000,000	937,000	877,000	1,684,000	1,295,000[11]
[illegible]	Urawan Mineral Belt	312,000	341,000	415,000	407,000	440,000	N.A.	N.A.	80,000
	Pine Creek	690,000[12]	715,000[13]	731,000[14]	750,000[15]	515,000	485,000	N.A.	N.A.
[illegible]	Continental	495,000	668,433	663,283	158,745[16]	546,097	711,754	519,280	N.A.
[illegible]	White Pine	9,003,750	3,860,000	3,221,000	3,136,158	3,000,000	3,513,000	4,153,000	1,857,200[17]

N.A. Not available. 1. Estimated. 2. Second shaft closed from March through December due to cave-in. 3. Permanently shut down, July 4, 1977. 4. Includes Immel, Young, Coy, and New Market. 5. Strike from March 11, 1976. 6. Strike from June 11, 1978 to July 16, 1979. 7. Nine-month strike. 8. Solution mines. 9. Closed 1977. 10. Permanently shut down July, 1977. 11. Closed 1978. 12. Includes Green River District, Pandora, Patti Ann-Elephant, Rim-Callahan-Sage, School Section-Standard, Velvet, Wood. 13. Closed June 1980. 14. Closed November 1980 due to flooding. 15. Figure indicates Hecla's share only. 16. 238 day strike in 1980. 17. Mine shutdown in 1982. See page 70 for complete details. 18. Closed July 3, 1980. 19. Closed September 1980. 20. 1980 production reduced by fire and strike. 21. Closed 1981. 22. Sold to Inspiration Copper in 1981. 23. On strike March 15 to November 17.

for metals. Increasing uses of substitutes—plastic, aluminum for copper, optical fibers, microwave communications—all cut the needs for metals. High production costs, cheap low cost non-United States production, very low import tariffs, increased imports, the slowing of annual growth rates for metals consumption, and truly the era of increasingly diminutive metal products all have played parts in the low production of metals in the United States.

Several silver mines, not surprisingly, raised production to all time highs during the year. Hecla Mining Company's Lucky Friday mine in Idaho raised output to 210,876 tons. Asarco Inc. increased output at its Galena mine in Idaho to 201,877 tons and raised output at its Black Cloud mine (also a lead-zinc producer) in Colorado to 212,640 tons. At the Black Pine mine of Inspiration Consolidated Copper Company in Montana, 202,372 tons of ore were mined.

The lesson is clear. Only very high grade underground mines or low cost mines such as Troy in the United States can be operated at a profit.

Open Pits Strip Less

Many mining companies made every effort to keep their open pit ore fed mills operating at capacity, but to cut costs they reduced stripping and this is evident at gold, copper, uranium, iron ore, and taconite pits.

Last year's trend toward new open pit gold mines in Nevada and to a lesser extent in Montana continued in 1982. And some of these gold mines had small production for heap leach testing and other metallurgical trials. For example, Cordex IV Syndicate mined a 10,000 ton sample for leaching at its Boulder Creed (Dee Gold) project in Nevada. This will be a major gold mine in the future. A major new pit was in Idaho where Superior Mining Company mined 200,000 tons of low grade gold ore and placed it on five heap leaching pads.

Late in the year there were reportedly 27 open pit gold mines in Nevada producing low grade gold ore for heap leaching.

Mines Less Underground Ore

Extended closures and production cut backs at underground mine operations resulted in many changes in the normal patterns of operations.

Only three major underground mines, all silver, were in continuous operation during the year. Sunshine Mining Company's 16 to 1 mine at Silver Peak, Nevada produced 138,158 tons of ore and at the Escalante mine of Rancher's Exploration & Development Company in Utah, 230,400 tons of ore were mined. Asarco Inc.'s new Troy mine in Montana produced about 2,700,000 tons to make it a major mine.

The San Manuel mine of Magma Copper Company was again the largest underground mine in the United States and production was cut less than at other big mines. There were 18,204,100 tons mined compared with the all time high of 22,197,558 in 1981.

By producing a record 4,176,934 tons of potash ore, Amax Chemical Corporation's New Mexico mine was the second largest producer. FMC Corporation's New Mexico Green River, Wyoming trona mine was third at 4,062,000 tons. While Amax, Inc. closed both its Climax and Henderson molybdenum mines in Colorado indefinitly on October 1st, both mines had operated at reduced rates earlier in the year. Henderson's production was 3,851,207 compared with 9,737,037 in 1981. Climax's underground ore production was 3,508,000 tons and was 10,792,887 in 1981.

An underground mine producing 10,000 tons of ore per day has long been considered to be a large mine. In 1982 there were only four of these mines—San Manuel, Amax Chemical, FMC Green River, and Henderson. Note that only two of these are metal mines.

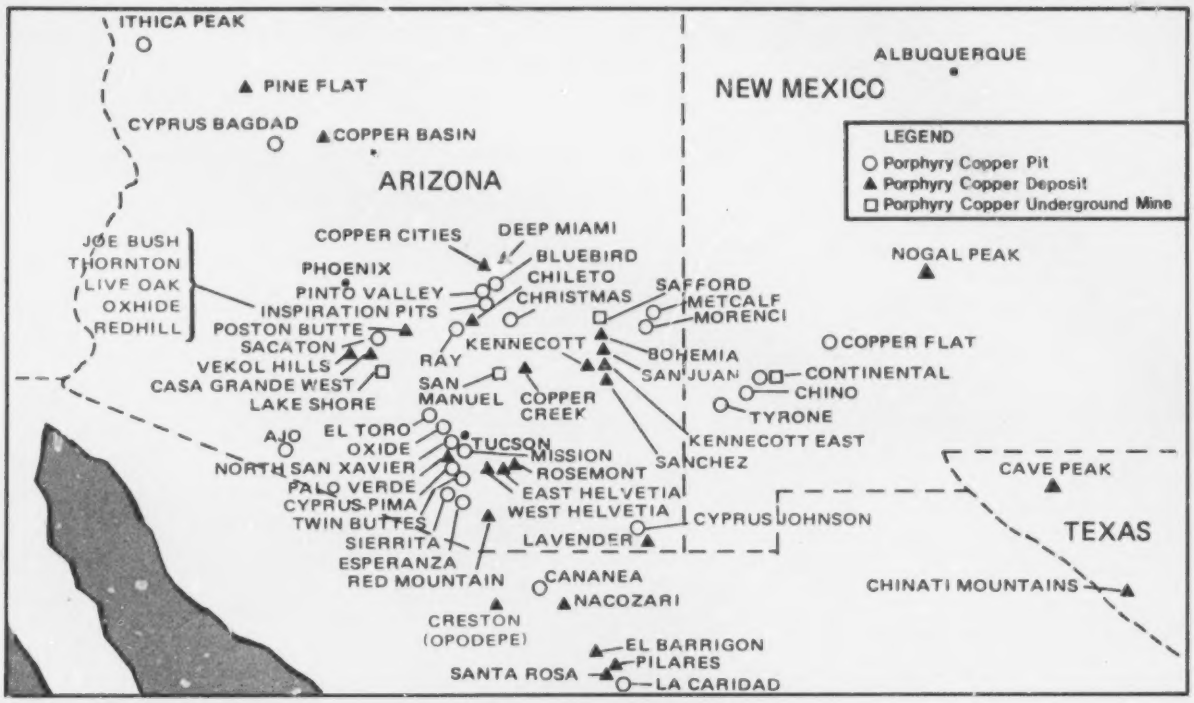
By far the largest open pit, and it has been the largest in tons of production for many years, was the Utah Division of Kennecott Minerals Company where 36,878,000 tons of ore (39,024,000 in 1981) and 118,012,000 tons of waste (134,274,849) were mined. This mine was operated throughout the year and the 1982 ore production could be considered normal as production during the last four years averaged 36,321,000 tons

Short tons of ore mined and waste stripped at key United States open pit mines

Company	Mine	1979 Ore Mined	1979 Waste Stripped	1980 Ore Mined	1980 Waste Stripped	1981 Ore Mined	1981 Waste Stripped	1982 Ore Mined	1982 Waste Stripped
Agrico Chemical Co.	Payne Creek	11,000,000	23,000,000	11,000,000	25,000,000	8,719,360	12,352,000	259,328	3,146,000
	Ft. Green	16,000,000	28,000,000	17,000,000	26,000,000	12,728,320	16,824,000[2]	11,852,800	15,039,000[2]
	Saddle Creek	1,300,000	2,800,000	2,000,000	6,000,000	2,152,960	3,606,000[2]	—[1]	—
Amoco Nat. Resources	Alligator Ridge	—	—	—	—	409,000	1,922,700	750,000	2,990,000
Asarco, Inc.	Mission	4,816,900	3,670,000	1,117,500	3,910,500	4,779,000	3,689,000	5,325,000	9,588,000
	Silver Bell	3,712,900	5,438,700	2,207,400	3,407,200	3,689,000	N.A.	—[1]	—
	Sacaton	4,005,600	12,361,800	3,818,700	11,784,800	4,103,000	N.A.	4,165,000	2,986,000
	San Xavier	870,000	1,391,500	502,000	3,957,200	1,740,000	N.A.	2,517,000	134,000
Anaconda Minerals Co.	Berkeley (East)	17,115,000	50,681,000	9,000,000	25,000,000[3]	15,000,000	40,000,000	8,000,000[2]	N.A.[1]
	Tonopah (Hall)	—	—	—	—	1,186,000	44,397,000	6,050,000[2]	22,561,845
Anamax Mining Co.	Twin Buttes	11,275,101	40,168,439	9,892,228	32,163,131	10,941,000	39,619,000	6,051,000	N.A.
Bear Creek Uranium Corp.	Bear Creek	420,000	19,500,000	540,000	15,800,000	625,748	15,578,389	497,723	12,988,548
Brewster Phosphates	Haynesworth	10,789,508	18,525,589	10,145,136	21,350,943	10,579,929	20,311,555	8,298,6953	16,281,425
	Lonesome	10,630,875	22,329,548	10,374,924	24,029,934	10,765,209	21,385,861	8,019,376[2]	16,166,643
Candelaria Partners	Candelaria	—	—	1,197,412	2,012,513	1,691,011	N.A.	700,000[2]	N.A.
Carlin Gold Mining Co.	Carlin	709,800	7,993,200	709,000	7,226,000	787,000	9,613,000	743,500	9,700,000
	Blue Star	226,300	835,200	229,000	326,000				
	Maggie Creek	—	—	251,000	1,916,000				
Chevron Resources Co.	Pinto Maria	770,000	12,000,000	970,000	18,000,000	929,000	12,500,000	1,300,000	12,500,000
Cities Service Co. Miami Copper Ops.	Pinto Valley	17,232,300	39,286,130	11,084,473	17,967,270	18,489,000	33,773,000	9,674,000[2]	17,418,000
Cleveland-Cliffs Iron Company	Tilden	15,883,000	16,100,000	21,775,000[2]	N.A.	N.A.	N.A.	11,334,887[2]	8,100,000
	Carnahan	3,100,000	2,600,000	1,300,000[2]	N.A.	—	—	—	—
	Republic-Humboldt	5,300,000	9,800,000	720,767	—	—	—	—	—
	Empire	17,718,000	28,600,000	15,500,000[2]	N.A.	N.A.	N.A.	10,295,382	10,817,000
Climax Molybdenum Co.	Climax	6,838,156	13,532,282	6,884,664	17,922,070	5,983,336	21,640,978	2,572,300[2]	6,854,882
Continental Oil Co.	Conquista	1,188,000	32,200,000	N.A.	N.A.	491,343	4,845,621[1]	104,288[2]	—
Cortez Mines Corp.	Cortez/Gold Acres	—	—	634,100	—	1,349,000	N.A.	1,535,000	10,500
Cyprus Mines Corp.	Cyprus Bagdad	14,593,136	26,179,782	14,943,300	22,782,000	14,794,000	28,460,000	N.A.	N.A.
	Cyprus Johnson	1,202,500	3,045,700	1,568,545	2,029,882	1,499,600	2,607,200	1,648,606	3,374,000
	Cyprus Pima	2,524,417[2]	13,218,297	7,307,944	45,882,310	11,416,490	34,882,317	3,869,923[2]	7,251,304
Cyprus Mining Co.	Thompson Creek	—	—	—	—	—	12,000,000	—	50,000,000[2]
Dawn Mining Co.	Midnight	642,806	3,900,950	180,000	4,560,000	171,700	N.A.	163,500	N.A.
Duval Corp.	Battle Mountain	955,200	6,804,500	1,085,600	8,078,860	1,233,600	11,083,300	1,400,000	12,680,000
	Esperanza	4,900,400	6,301,700	6,187,500	4,613,100	6,176,500	12,234,900	—[1]	412,000
	Mineral Park	6,321,605	10,782,205	6,258,100	10,981,601	6,230,500	9,023,600	—[1]	—
	Sierrita	33,413,201	30,595,500	33,856,000	39,256,300	32,614,300	35,742,400	16,138,000[2]	9,787,000
Eisenhower Mining Co.	Eisenhower	8,959,800	27,311,600	7,276,800	18,858,800	2,994,000	N.A.	2,123,000	17,304,000
Estech General Chemicals Co.	Watson	3,973,000	7,802,000	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	Silver City	4,010,000	3,160,000	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Eveleth Taconite Co.	Thunderbird	18,476,052	13,053,000	17,748,497	15,805,641	18,409,634	12,500,000	14,539,261	6,865,338
Exxon Company, U.S.A.	Highland Uranium	1,153,700	46,081,200	921,500	41,463	N.A.	N.A.	N.A.	N.A.
Federal Bentonite Co.	Upton	142,000	1,300,000[2]	198,000	1,800,000	N.A.	N.A.	N.A.	N.A.
	Colony	587,000	3,400,000	100,000	9,000	N.A.	N.A.	N.A.	N.A.
Freeport Gold Co.	Jerritt Canyon	—	—	—	—	577,000	N.A.	800,000[2]	N.A.
Gold Fields Mining Co.	Ortiz	—	—	—	—	980,000	300,000[2]	863,362	5,480,000
Golden Sunlight Mining Company	Golden Sunlight	—	—	—	—	—	—	—	5,740,000[2]
W.R. Grace Co.	Stony Lake	4,506,700[2]	13,425,700[2]	5,051,600[2]	13,021,400[2]	2,800,000	N.A.	N.A.	N.A.
	Hooker's Prairie	6,576,200[2]	8,810,900[2]	7,665,700[2]	10,109,700[2]	1,500,000	N.A.	N.A.	N.A.
Hanna Mining Co.	Groveland	5,252,945	9,356,342	—	—	—	—	—	—
	Hanna Nickel	2,194,847	1,627,740	N.A.	N.A.	N.A.	N.A.	—[1]	—
	Butler Taconite	7,563,912	2,138,388	4,900,000	1,697,032	N.A.	N.A.	21,282,796	4,772,828
	National Pellet	19,284,494	9,453,327	7,300,516	481,000	8,425,000	1,200,000	2,951,813	390,445
Houston International	Borates	—	—	—	—	104,000	303,000	N.A.	N.A.
Inland Steel Co.	Minorca	4,500,000[2]	1,500,000[2]	5,161,776	2,081,080[2]	8,067,487	4,600,000	58,281,251	2,385,960
Inspiration Consolidated Copper Co.	Christmas	820,000	2,461,000	1,292,000	4,011,000	900,000[2]	3,500,000[2]	—	—
	Red Hill	38,000	3,546,000	10,127,000	12,962,000	15,946,000	25,944,000	15,456,000	21,872,000
	Thornton	3,567,000	6,586,000						
	Joe Bush	2,262,00	9,550,000	4,347,500	21,500,000				
	Inspiration (all)	6,105,000	19,810,000						

Company	Mine	1979 Ore Mined	1979 Waste Stripped	1980 Ore Mined	1980 Waste Stripped	1981 Ore Mined	1981 Waste Stripped	1982 Ore Mined	1982 Waste Stripped
International Minerals & Chemical Corp.	Clear Springs Noralyn Kingsford	11,261,000 17,871,000 16,880,000	7,910,000 17,579,000 28,803,000	9,820,000 16,199,000[4] 13,087,000	8,413,000[4] 12,211,000[4] 19,656,000	10,505,000 15,628,000[4] 13,190,000	4,665,000[4] 9,730,000[4] 21,044,000[4]	9,600,000	N.A.
Jackson County Iron Co.	Black River Falls	2,096,196	6,965,395	1,990,807	5,415,973	1,000,000[2]	4,000,000[2]	1,000,000[2]	1,300,000[2]
Jones & Laughlin Steel Co.	Hill Annex (Main Pit) McKinley Mine	196,925 558,601	— 272,512	— 982,089	— 845,368	— —	— —	— —	— —
Kaiser Steel Corp.	Eagle Mountain	9,033,152	35,296,400	6,751,296	25,609,900	7,213,795	26,252,400	—	—
Kaycee Bentonite Co.	Kaycee Bentonite Ten Sleep	N.A. N.A.	N.A. N.A.	201,000 221,000	650,000 1,050,000	N.A. N.A.	N.A. N.A.	N.A. N.A.	N.A. N.A.
Kennecott Minerals Company	Chino Div. Ray	7,162,501 14,202,000	24,800,000[2] 30,000,000[2]	5,432,000 10,963,460	20,500,100[2] 33,010,214	7,520,000 14,816,000	47,898,000 27,878,960	5,305,000 4,787,000	27,860,000 11,015,000
Kingham	37,804,000	123,181,836	31,578,000	107,000,000	39,024,000	134,274,849	36,978,000	118,012,000	
Kerr-McGee Corp.	Wyoming Uranium	276,345	3,707,463[1]	183,991	979,321	104,492	N.A.	N.A.	N.A.
Lone Star Steel Co.	Lone Star	N.A.	N.A.	1,150,155	2,065,699	N.A.	N.A.	N.A.	N.A.
Magco Minerals Corp.	Delamar	805,000	3,777,000	750,000	5,440,000	875,690	5,327,280	965,135	5,049,991
McDermitt Joint Venture	McDermitt	246,700	1,377,500	N.A.	N.A.	273,000	910,351	237,000	1,243,000
Mobil Chemical Co.	Fort Meade Nichols	12,700,000 6,400,000	12,000,000 11,200,000	14,300,000 6,100,000	16,100,000 11,500,000	4,500,000	19,000,000	N.A.	N.A.
Molycorp, Inc.	Mountain Pass Questa	298,760 N.A.	201,830 N.A.	387,000 611,000	219,000 1,658,000	N.A. —[5]	N.A. —	N.A. —	N.A. —
Monsanto Co.	Tennessee Mines Henry	2,200,000 750,000	6,600,000[2] 3,000,000[2]	900,000 700,000	3,000,000 2,800,000	[6]N.A. [6]N.A.	N.A. N.A.	N.A. N.A.	N.A. N.A.
Pathfinder Mines Corp.	Lucky Mc. Shirley Basin Big Eagle	357,586 670,270 159,831	5,471,247 28,000,000[2] 2,700,000[2]	291,564 632,000 395,000	8,660,608 26,750,000 6,633,000	209,291 467,747 133,530[7]	4,726,940 15,980,963 795,842	128,143 220,307 —	2,256,646 9,860,966 —
Pegmue Gold Ltd.	Zortman Mine Landusky Mine	— —	— —	218,000 500,000	200,000 500,000	675,000 615,000	620,000 724,000	1,889,000 1,889,000	1,334,000 1,827,000
Petrotomics	Felder Operations Section 4	N.A. 4,000	N.A. 61,000,000	N.A. 351,555	N.A. 54,473,000	399,501	27,989,000	—	—
Phelps Dodge Corp.	Morenci Ajo (New Cornelia) Ajo Extension Tyrone Metcalf Pit	21,712,798 10,188,883 — 17,770,783 9,226,043	29,132,171 10,435,815 — 62,347,498 21,259,790	17,692,768 7,042,202 — 16,499,008 2,416,765	29,558,944 8,956,647 — 68,324,802 7,612,107	28,740,707 9,609,354 8,757,000 14,821,362 —[10]	45,966,583 13,480,391 — 56,691,070 —[10]	15,509,000 9,710,000 1,243,000 3,744,000 —	12,266,000 4,633,000 — 14,982,000 —
Pickands Mather Co.	Erie Mining Hibbing Taconite	26,035,016 23,592,004	24,207,341 14,295,777	16,778,798 27,992,000	21,209,050 8,000,000	23,772,622 25,035,147	21,569,342 12,607,156	11,876,092 20,029,873	9,232,634 10,518,260
Pinson Mining Co.	Pinson Pit	—	—	121,742	1,877,244	4,414,048	N.A.	496,771	4,324,999
Quintana Mining Co.	Hillside	—	—	—	—	—	5,300,000	N.A.	N.A.
Ranchers Exploration & Development Corp.	Bluebird	3,779,043	2,942,561	3,993,123	4,479,711	231,926	N.A.	—[3]	—
Reserve Mining Co.	Peter Mitchell	20,756,[illegible]	5,651,627[1]	14,948,151	1,637,138	25,991,000	5,765,897[1]	4,928,616	1,045,200
Reynolds Mining Corp.	Bauxite	621,000	5,600,000	481,000	5,800,000	N.A.	N.A.	N.A.	N.A.
Rhode & Fryberger Inc.	Rana Sharon[2]	— 107,969	742,923 —	369,610 —	468,656 —	N.A. N.A.	N.A. N.A.	N.A. N.A.	N.A. N.A.
J.R. Simplot Minerals & Chemicals Div.	Conda Gay	1,580,083 1,796,129	5,421,755 8,393,934	1,500,000 1,700,000	4,500,000 8,300,000	1,910,000 7,750,000	8,120,000 12,700,000	N.A. N.A.	N.A. N.A.
Smokey Valley Div. Copper Range Co.	Round Mountain	1,501,640	2,407,990	N.A.	N.A.	2,331,000	8,714,000	2,899,000	5,960,000
Standard Slag Co.	(all)	175,353	470,720	158,585	602,931	N.A.	N.A.	N.A.	N.A.
Texasgulf Inc.	Lee Creek	4,586,000	9,500,000	10,110,372	30,659,517	8,835,000	33,367,000	N.A.	N.A.
Union Carbide	Gas Hills Hot Springs King City	476,000 136,000 —	12,060,000[2] 163,000 —	465,700 165,000 104,000	23,140,000[4] 400,000 143,000[4]	N.A. N.A. —	N.A. N.A. —	N.A. N.A. —	N.A. N.A. —
UV Industries Inc.[5]	Continental Mine	1,441,442	860,797	1,711,489	934,072	1,440,862	4,294,223	N.A.	N.A.
U.S. Borax & Chemical Corp.	Boron	3,424,370	12,651,500	3,585,286	20,798,750	N.A.	N.A.	N.A.	N.A.
U.S. Steel Corp.	Minntac Sherman Atlantic City Desert Mound	56,088,087 — 4,347,000 584,000	12,775,131 49,813 3,487,000[2] 2,160,000	49,000,000 — 4,631,000 13,000	11,394,379 — 3,577,000[2] 134,000	42,369,406 194,276 4,610,000 N.A.	14,800,000 N.A. 4,155,000[2] N.A.	11,706,578 — 2,700,000[2] N.A.	5,754,545 — 2,900,000 N.A.

N.A. Not available. 1. Cubic yards. 2. Estimated. 3. Mine shutdown for a period in 1982—see page 70 of this issue for complete details. 4. Includes Beck, Atlanta, P&S, Hot Creek, Siltex, and Pacific. 5. Formerly United States Smelting and Refining Company. 6. Closed indefinitely. 7. Shutdown August 1981. 8. Mine resumed operations after 21 months of shutdown. 9. Shut down for 1 year. 10. Closed 1981.



Extent of the Mine Closings

The following tabulation lists the mine name and the dates of mine shutdowns, temporary and/or permanent, in 1982. The detail from the WORLD MINING Porphry Copper map, above, shows the center of the United States copper mining industry, the Southwest. The information below shows that virtually every major copper operation curtailed production last year.

Atlantic City—Closed June 6 to August 22 and September 15 to October 26
Bluebird—Closed all year
Black River Falls—Closed April 9
Bunker Hill—closed in July
Candaleria—Closed in June
Carr Fork—Closed in October
Chino—Closed April 1 to July 31
Christmas—Closed all year
Erie—Closed April 1 to July 31
Empire—Closed May to November
Esperanza—Closed all year
Haynsworth—Closed July 19 to October 4
Henderson—Closed October 1
Hibbing—Closed July 4 to September 3, November 21 to 28 and December 24 to 28
Hot Springs—Closed June 15 to year-end
Jefferson City—Closed May till year-end
Lonesome—Closed July 19 to October 4
Magma—Closed August 15 to year-end
Mineral Park—Closed 12 months
Mintac—Closed June 6 to year-end
Nash Draw—Seven months reduced operating schedule
Pea Ridge—Closed during October
Pima—Four day week started February 1. Mine closed June 4 to year-end
Pine Creek—Closed most of the year
Pinto Valley—Closed June 27 to year-end
Ray—Closed May 1 to year-end
Saddle Creek—Closed 12 months
Sherman—Closed 12 months
Sierrita—Closed three months, reduced schedule nine months
Silver Bell—Closed 12 months
Sunshine—Closed mid-June to mid-December
Star—Closed permanently in June
Tilden—Closed from May through September
Trixie—Closed in late November
Warm Springs—Closed 10 weeks
White Pine—Closed on October 1 until year-end

of ore per year. Asarco Inc. actually mined more tons of ore and waste during the year at its Mission pit in Arizona than it did in 1981.

There were two new large molybdenum pits. In Idaho, Cyprus Mining Company stripped about 50,000,000 tons at its Thompson Creek mine in preparation for initial mill operation in mid-1983. Anaconda Minerals Company started its molybdenum mill at its Tonopah (Hall) mine in late 1981 and milled 1,186,000 tons of ore before the mill was shut down awaiting a better market for molybdenite. Before year-end 6,050,000 tons of ore was mined. However, stripping was reduced, and by year-end 22,561,845 tons had been moved; this waste was used to build a tailings dam.

The authors have spent more time on this article than is normal. The results are not as favorable and the tables are incomplete. The facts are that with so many mines closed or with engineering staffs so reduced, it has been nearly impossible in some cases to reach the person having the figures. Often only a watchman was to be found at a mine. Nevertheless, this article continues to give more facts on mine production in the United States than any other published source of information.

There is a growing trend for companies including Inspiration Consolidated Copper Company, International Minerals and Chemical Corporation, and Carlin Gold Mining Company to total all production from a number of mines, mostly in one state, and release this figure rather than those for individual mines. When the questionnaires were sent out, the question was asked "Comments?" A typical reply was as follows: "Permanent shutdown. A classic failure of of industry, government, and labor to work together. The metal units still lie in the ground." ■

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World Mining

OCTOBER 1983

SPECIAL REPORT:

Crushing & grinding

In-pit crushing signals new efficiency 41

OCTOBER 1983
VOLUME 36, NO. 10

World Mining

THE COVER

Two examples of in-pit crushing: the larger photo shows part of the complex at Iscor's Sishen iron ore mine in South Africa; the smaller photo is of a portable apron feeder at Duval's Sierrita copper mine in the United States. WORLD MINING examines the latest advances in crushing and grinding this month in a special report. Also the subject of a special report this month is the mining technology of Japan.
Photographs by Iscor Limited and Duval Technology Engineering & Construction Company (Dutec).

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Higher energy costs and low metals prices, have caused the mining industry to focus on smaller, higher grade deposits. Exploration, mining methods, and beneficiation configurations are adapting to this

Second Small Mines symposium held in Helsinki

When the First International Symposium on Small Mine Economics and Expansion was held in Taxco, Mexico in 1981, the shift of mining company thinking toward smaller operations had just begun. Large corporations were just beginning to form Small Mines divisions and to refocus exploration efforts. From June 12-16, 1983, over 200 delegates from 34 countries convened for the Second International Symposium on Small Mine Economics and Expansion in Helsinki, Finland. The symposium was sponsored by WORLD MINING and WORLD COAL.

Once again, several large companies were represented. Small mines are not only for small companies anymore. The largest delegation was from the largest Finnisn mining company, Outokumpu Oy. Several papers were presented by engineers from this company as well. Delegates had the opportunity to visit two of Outokumpu's mines—Vuonos and Keretti—during the course of the symposium.

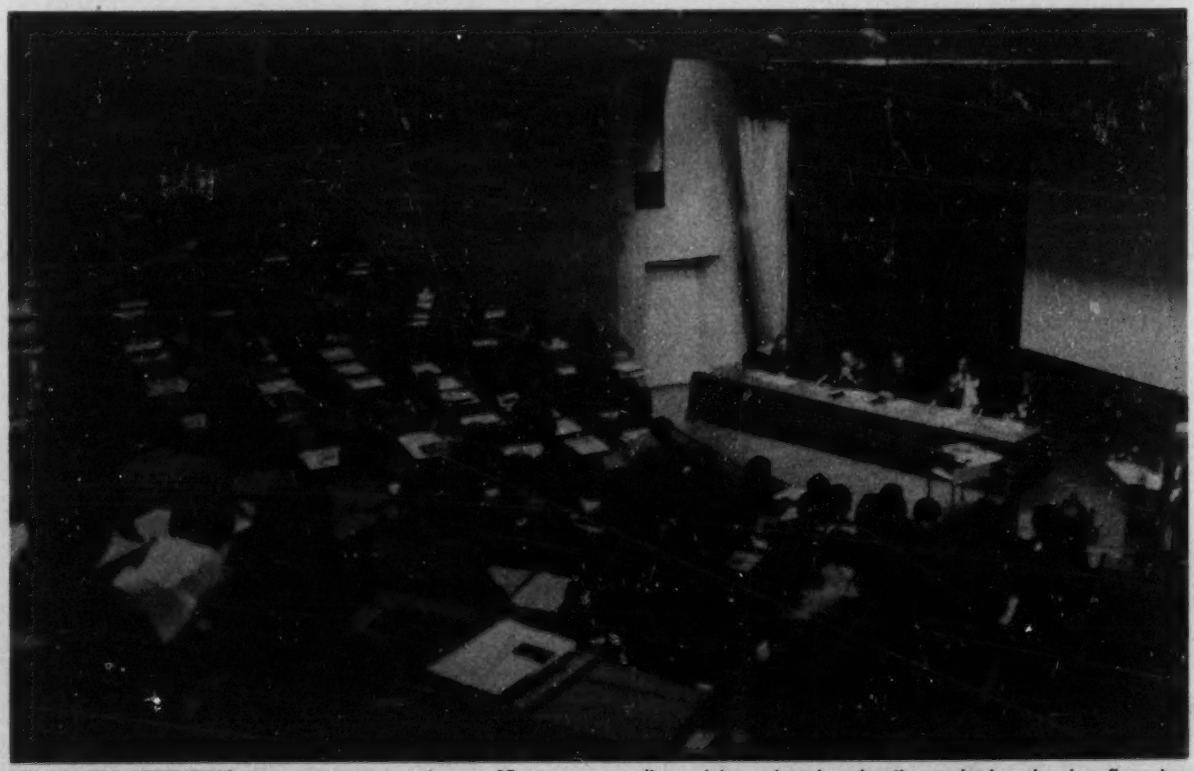
In addition to two sessions on "Operating Considerations," half-day sessions on the following topics were held: "Small Mining Opportunities," "Exploration and Planning," and "Financing and Marketing."

Future of Small Mines

After the keynote address on the Finnish mining industry delivered by Pentti Voutilainen, president of Outokumpu Oy, George F. Leaming, principal consultant for Western Economic Analysis Center, Arizona, United States, presented a very interesting paper on the future of small and medium size mines in world base metal markets. As a starting point for his predictions, Leaming reviewed the historical role of small and medium mines in the production of various metals (See Table 1).

Based on his analysis, Leaming concludes that the principal implication of the current outlook for those involved in mineral exploration is that small anomalies and small target mineral deposits could very well become profitable mines during the next 20 years if those deposits contain iron, chromite, cobalt, nickel, tungsten, copper, lead, zinc, magnesium, or titanium, or some combination thereof—and the more the better. At the same time, small deposits of manganese, molybdenum, vanadium, tin, or bauxite are not likely to become attractive investments unless they are of exceptionally high grade and possess other characteristics that will allow very low production costs.

For those who already have a metallic mineral deposit and must decide on the nature of the development and investment to be made, the outlook indicates



DELEGATES ATTENDING the symposium heard some 25 papers covering four important subject areas—opportunities in small and medium mining, mineral exploration and mine planning, financing projects and marketing final product, and operating considerations.

that, even if the deposit is large, serious consideration should be given to small and medium scale operations if that deposit contains iron, chromite, cobalt, nickel, tungsten, copper, lead, zinc, magnesium, or titanium. The actual determination of mining scale, of course, should depend on the results of a thorough geologic, engineering, and economic analysis of any proposed project, including consideration of various alternative scales of operation and potential market impacts.

For those now producing chromite, cobalt, tungsten, or lead on a small or medium scale, the short term outlook (to 1986) indicates that serious consideration should be given to expanding output as much as possible with existing facilities. For those small and medium size mines where those minerals occur but are not being produced, the outlook strongly implies that serious consideration should be given to attempts to recover and market those minerals.

Michel Bilodeau, Director of the mining engineering program at McGill University in Canada, presented a systematic method for an economic analysis of the exploration and development of small mineral deposits. Bilodeau used two hypothetical deposits—one gold and one copper-zinc-silver—to illustrate his methodology. Tables 2 and 3 show one aspect of his approach, the sensitivity of project economics to long-term price forecasts. Bilodeau concluded that historical evidence in most countries shows that exploration for and exploitation of small deposits is a profitable business, but they are not easy tasks. All key factors governing the economic viability of small mineral deposits must be well known and understood if the majority of industry's efforts and resources are to be concentrated on those areas which promise adequate economic returns.

Computers Cut Costs

With metals prices currently in what Bilodeau would term the "lower-limit" range, mine operators have had to devise methods for most cost-effective operations at existing properties. Finland, with its low grade complex ore bodies has been a leader in cost control. Two papers at the symposium focussed on how Finnish operations achieve their low costs: "Advanced Investigation Methods and an Interactive Stope Planning System for Heterogeneous Ore Deposits" by Ole Lindholm of Rataruuki Oy and and Olavi Paatsola of Kemira Oy; and "Economic Stoping of Small Ore Bodies" by Jorma Porkka, Esko Orivuori, and Eero Soininen, Outokumpu Oy. In both cases, emphasis is given to proper information and advanced methods of manipulating the information. The multi-database approach used by Outokumpu is illustrated in Figure 1. This computerized approach allows improved planning and reporting.

Schematic representation of the ADP-solutions — Figure 1

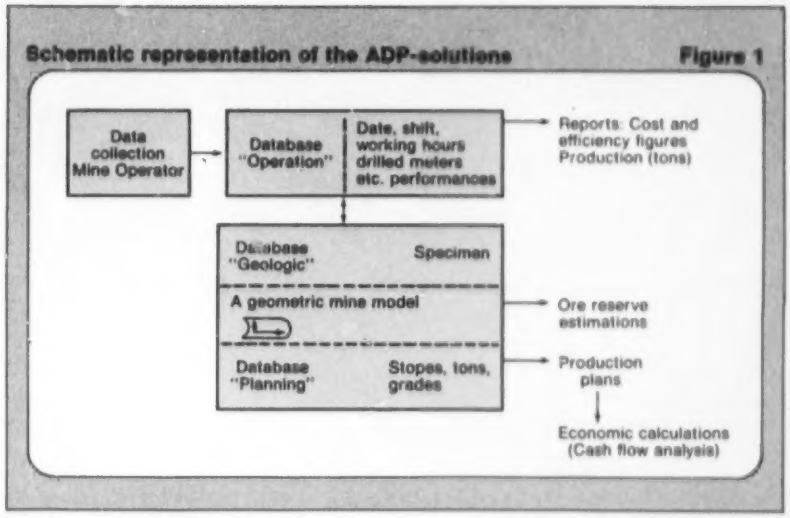


Table 1.
Importance of small and medium size mines in world base metal markets

	Percentage of total primary supply in market economy countries provided by small and medium size mines							
	1960	1965	1970	1977	1978	1979	1980	1981
IRON AND FEROALLOY METALS								
Iron Ore	12.5	14.8	13.9	8.6	7.5	6.1	5.1	4.8
Chromite	76.0	76.8	76.4	73.8	73.8	72.9	75.0	
Cobalt	8.8	12.3	3.0	12.8	11.8	10.0	9.4	10.5
Manganese Ore	55.4	54.6	45.8	12.1	10.0	9.4	NA	
Molybdenum	NA	NA	NA	1.2	1.0	0.8	1.2	1.5
Nickel	12.6	12.7	12.2	15.5	16.8	16.6	15.7	16.8
Tungsten	75.7	63.4	69.4	79.5	77.8	78.6	77.5	73.9
Vanadium	90.7	83.3	73.6	46.9	42.4	46.1	45.1	49.9
NONFERROUS BASE METALS								
Copper	10.7	11.4	9.7	9.7	8.4	8.5	8.7	8.4
Lead	60.0	54.6	49.8	51.7	51.1	50.6	51.5	53.8
Tin	18.5	20.0	24.6	31.3	29.6	28.6	27.9	28.7
Zinc	80.8	80.1	67.9	59.2	58.9	57.8	58.3	58.2
LIGHT METALS								
Aluminum	28.5	26.5	17.5	10.1	9.7	9.2	8.2	8.3
Magnesium	54.1	49.2	47.8	47.1	44.7	44.7	44.4	45.1
Titanium	NA	NA	NA	14.7	14.4	13.1	12.5	NA

NA means not available
Source: Western Economic Analysis Center

With computers becoming more economical to buy, even for small miners, a good deal of attention was given to their applications for small mines. In addition to the above papers, Kai Nielson, Senior Lecturer at the Norwegian Institute of Technology presented a paper on the use of computers in the Norwegian mining industry; Ross Dalton, Managing Director of ANER Research, reviewed United States mine planning packages that are available for desktop computers; and Mike Chender, President, Metals Economics Group, United States, as part of his presentation on information for small miners referred to the use of and access to large databases for economic information. Also one evening during the symposium was devoted to a round-table discussion on the use of microcomputers in mining.

One other way of reducing costs is to do as much development as possible in the ore body iteself rather than in host rock. Methods for doing this by adapting the mining method were presented by J. Gölling, Ingenieurbüro für Bergbauplanung in der Rohstoffindustrie, Federal Republic of Germany.

Roger Andersson, Manager of Technical Development, LKAB, Sweden, explained how his company has been attempting to reduce costs by standardizing underground service equipment. LKAB has used as a standard unit, the Volvo BM 4200. The ser-

Table 4.
Comparison of caravan, module, and on-site mills

	Engineering	Site work	Lead time	Maximum rated capacity (tons per hour)
Caravan Mill	negligible	slight	minimum	12-15
Module Plant	moderate	moderate	moderate	25-30
Site Construction	considerable	considerable	considerable	Any

OVER 200 attendants from more than 35 countries met in Helsinki; both large companies and small were represented.

vice operations involved in testing are road maintenance, final clearance of blasted rubble from the mine face and transportation of gravel by bucket. The machine also serves as a carrier for mechanized scaling equipment.

Mobile versus Central Mills

Key to many small tonnage operations is the beneficiation process. At the first symposium in Mexico a good deal of attention was drawn to the idea of portable mills—trailer mills or caravan mills are trade names used by KHD (West Germany) and Sala (Sweden), respectively. Once again in Helsinki, this concept drew attention. Dag Ingler, Chief Consultant for Sweco, Sweden compared economic and practical comparisons of caravan, module, and on-site mills (see Table 3).

Helmfried Lechner, Senior Supervisor, Exploration, German Federal Ministry of Economics presented the following features of Trailer Mills:

- Trailer mills are processing equipment for continuous operation suitable for performance ratings of 50 to 500 tons of ore per day.
- Trailer mills are delivered by the manufacturer with complete wiring and piping so that they can become operational at the site without delay.
- Their processing technology and performance can be adapted to various types of ores.
- The modular construction principle makes capacity extensions easy at any time.
- Land and sea transportation do not present problems.
- Location of the mills does not present any problem. Any sufficiently large area with competent ground can accomodate the mill.

An alternative to mobile mills is the concept of a central concentrator which can beneficiate ores from several small mines. Birger Kolsrud, Chief Consulting Engineer, and Ivar Larsson, Senior Metallurgist, of Boliden Mineral AB (Sweden) explained how their company has used a central concentrator economically.

One of the advantages of this approach has been that operating costs per ton of ore will be lower than in a small local mill. This is due to the fact that the fixed costs are distributed over a larger tonnage. In a larger mill, the wages represent about 16 percent of the operating costs compared to about 25 percent for a smaller mill, in spite of the fact that the manpower is greater and the personnel more qualified in a larger plant.

It is of importance that lower capital and operating costs, imply that the cut-off grade of the ore deposit can be lowered, which affects the quantity of reserves. The economic advantages of a central mill also mean that more advanced process control systems can be installed. The temporary variations in grades and compositions of the polymetallic ores treated at Boliden can be substantial. Boliden's central concentrators at Boliden and Kristineberg are both equippped with on-stream analyzers and process control systems.

Tailings disposal costs can be reduced by having one rather than several impoundment areas. In Boliden's case, the capacity of a larger mill for high capacity sands production from tailings gives greater flexibility for the company's mine backfill operations as well.

One of the disadvantages of a central concentrator is that it cannot be custom designed for a given ore. For instance in cases where autogenous grinding would lend itself well to a particular ore, it cannot be implemented if other ores that are not amenable to autogenous grinding are to be fed to the central mill. The advantages have outweighed this disadvantages for Boliden.

Other processing papers dealt with plant design, thin-layer leaching of oxidized copper ores in Chile, economics of preconcentration, and small heap leaching operations in the United States. The proceedings are available for US$147.00 from WORLD MINING Technical Services, 500 Howard Street, San Francisco, California 94105, United States.

Small and medium mining continue to steadily gain importance. Because of this importance, Phelps Dodge Corporation, United States, two years ago, just after the first Small Mines symposium, established a small mines division. The French Administration—Service of Raw Materials and Underground Operations at the Ministry of Industry and Research has introduced a movement grouping French organizations concerned with small mining into a single association. This movement is called the French Association for Worldwide Development of Small Mines.

Because of the strong continued interest in this subject, the Third International Symposium on Small Mine Economics and Expansion has been scheduled for June 1985 in Toronto, Ontario, Canada. To be placed on the promotion list for this symposium write to WORLD MINING. ■

Table 2.
Long-term commodity price ranges

Commodity	Price bases (US dollar)	Lower-limit price	Expected price	Upper-limit price
Copper	pound	0.95	1.15	1.40
Zinc	pound	0.45	0.55	0.65
Silver	ounce	10.00	13.00	20.00
Gold	ounce	400.00	550.00	800.00
Exchange rate	US dollar per Canadian dollar	0.95	0.80	0.70

Table 3.
Sensitivity of project economics to long-term price forecasts

Net present value at the start of development—million dollars (Rate of return—percent)	Cu-Zn-Ag Deposit	Au Deposit
Lower-Limit Prices	−43.38	0.58
	(−23.7)	(8.3)
Expected Prices	0.80	50.16
	(8.4)	(34.3)
Upper-Limit Prices	41.60	125.51
	(26.8)	(62.9)

For more information, Circle No. 75